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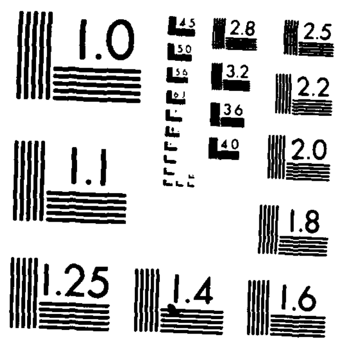

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MANAGEMENT OF ELECTRONIC
TEST EQUIPMENT

VOLUME III: ORGANIZATIONS, POLICIES
AND PROCEDURES

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MANAGEMENT OF ELECTRONIC TEST EQUIPMENT

VOLUME III: ORGANIZATIONS, POLICIES, AND PROCEDURES

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1. INTRODUCTION

TEST EQUIPMENT CATEGORIES

Test, measurement, and diagnostic equipment (TMDE) is defined as any system or device used to evaluate the operational condition of a system or equipment to identify or isolate (or both) any actual or potential malfunction.[1] Electric/electronic TMDE is further subdivided into manual electronic test equipment (ETE), automatic test equipment (ATE), test program sets (TPSs), and calibration equipment. The latter category consists of several echelons of calibration standards (reference and transfer standards) to ensure traceability of measurement to national standards.

The principal distinction affecting the management and support of ETE and ATE in the Department of Defense (DoD) is whether the test equipment is "general purpose" (i.e., common) or "special purpose" (i.e.,peculiar). These terms are defined in MIL-STD-1309C as follows:

- General-purpose test equipment. Test equipment which is used for the measurement of a range of parameters common to two or more equipments or systems of basically different designs.

- Special-purpose test equipment. Equipment used for test, repair, and maintenance of a specified system, subsystem, or module, having application to only one or a very limited number of systems.

General-purpose test equipment is normally classified under Federal Supply Class (FSC) 6625, "Electrical and Electronic Properties Measuring-Testing Instruments," whereas special-purpose test equipment can be found under many different FSCs. Table 1-1 lists those FSCs from the total of 645 classes/standardization areas that, based on title, may include test equipment.[2] Because the above definitions leave some latitude, however, general-purpose test equipment, if interpreted as any ETE supporting two or more different weapons systems, can be found in many FSCs other than

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[1]Military Standard (MIL-STD) -1309C, "Definitions of Terms for Test, Measurement and Diagnostic Equipment" (Washington, D.C.: Naval Electronic Systems Command, 18 November 1983).

[2]Department of Defense, Standardization Directory, Defense Standardization and Specification Program, SD-1 (Washington, D.C.: U.S. Government Printing Office, 1 April 1984).

TABLE 1-1. FEDERAL SUPPLY CLASSIFICATION OF TEST EQUIPMENT

FSC	TITLE	ASSIGNEE ACTIVITY[1]
1190	Specialized Test and Handling Equipment, Nuclear Ordnance	DS
1398	Specialized Ammo Handling and Servicing Equipment	AR
1450	Guided Missile Handling and Servicing Equipment	99
1730	Aircraft Ground Servicing Equipment	99
1850	Space Vehicle Handling and Servicing Equipment	19
3470	Machine Shop Sets, Kits, and Outfits	IP
3590	Miscellaneous Service and Trade Equipment	GL
4910	Motor Vehicle Maintenance and Repair Shop Specialized Equipment	AL
4920	Aircraft Maintenance and Repair Specialized Equipment	99
4921	Torpedo Maintenance Repair and Checkout Specialized Equipment	OS
4923	Depthcharge and Underwater Mine Maintenance Repair Checkout Specialized Equipment	OS
4925	Ammunition Maintenance, Repair and Checkout Specialized Equipment	OS
4927	Rocket Maintenance, Repair and Checkout Specialized Equipment	MI
4931	Fire Control Maintenance and Repair Shop Specialized Equipment	AR
4933	Weapons Maintenance and Repair Shop Specialized Equipment	AR
4935	Guided Missile Maintenance, Repair and Checkout Specialized Equipment	99
4940	Miscellaneous Maintenance and Repair Shop Specialized Equipment	AL
4960	Space Vehicle Maintenance, Repair and Checkout Specialized Equipment	19
5210	Measuring Tools, Craftsmen	99
5220	Inspection Gages and Precision Layout Tools	AR
5280	Sets, Kits, and Outfits of Measuring Tools	GL
59 (Group)	Electrical and Electronic Equipment Components (23 FSCs)	various
6080	Fiber Optic Kits and Sets	ES
6540	Opticians Instruments, Equipment and Supplies	DP
66 (Group)	Instruments and Laboratory Equipment (19 FSCs)	various[2]
7035	Administrative Data Processing Support Equipment	02
7045	Administrative Data Processing Supplies and Support Equipment	02

[1]Codes as identified in Standardization Directory, ibid.: AL = Armament Munitions and Chemical Command; AR = Armament Research and Development Command; DP = Defense Personnel Support Center; DS = Defense Nuclear Agency; ES = Defense Electronics Supply Center; GL = Natick Research and Development Center; IP = Defense Industrial Plant Equipment Center; MI = Missile Command; OS = Naval Sea Systems Command; 02 = Directorate of Computer Resources, HQ USAF; 19 = Space Division (Air Force Systems Command); 99 = Air Force Logistics Command Cataloging and Standardization Center.

[2]Includes FSC 6625 for which the Army's Communications-Electronics Command (CECOM) is the assignee activity.

FSC 6625; conversely, special-purpose test equipment may be found in FSC 6625. In addition, a piece of test equipment for a new weapons system may initially be classified as special purpose, but then later be reclassified as general purpose when it is used in support of other weapons systems. Its initial classification, however, may not be changed. Furthermore, the Military Services may use different ancillary items (e.g., plug-ins) for the same basic test instrument, so that different National Stock Numbers (NSNs) may apply to the same basic instrument stocked with different ancillary items. Additionally, such an ancillary item may be peculiar to a particular weapons system so that an item of general-purpose test equipment is actually used, and may be so classified, as special purpose.

Generally, special-purpose test equipment is managed in conjunction with the supported prime weapons system or subsystem(s), whereas general-purpose test equipment is managed by a separate functional manager. Importantly, the most recent edition of the DoD Standardization Directory specifies that ATE and its accessories be classified under FSC 6625 – a new requirement that confuses the distinction between general-purpose and special-purpose ATE.

The acquisition and life cycle support of TPSs is also generally managed in conjunction with the associated prime equipment assemblies or modules, while that of calibration equipment is a separate functional area within each of the Military Services.

DEFENSE POLICY GUIDANCE

The acquisition and life cycle support of test equipment are management functions that have been delegated to the Military Services by the Office of the Secretary of Defense (OSD). Existing DoD directives and instructions pertaining to acquisition focus primarily on prime equipment, with support equipment treated as an integrated logistic support (ILS) element. With respect to the latter, the policy emphasis is on (1) early identification, tradeoffs, and determination of ILS requirements through an adequately funded ILS program and Logistic Support Analysis (LSA) effort; and (2) adequacy of programmed support resources to meet prime equipment readiness requirements, considering initial and mature reliability and maintainability values and field experience on similar

equipment. DoD policy on the acquisition and support of test equipment is described in detail in Volume IV of this report.

With respect to the management and support of materiel once it enters the DoD inventory, current directives and instructions, with some exceptions, do not discriminate between prime and support equipment. Moreover, the various management aspects (e.g., standardization, maintenance concept/plan, provisioning, diminishing manufacturing sources, quality assurance, economic repair limits, technological obsolescence, and monitoring or reporting of availability) are addressed individually and separately in numerous documents.

REPORT ORGANIZATION

The Military Services' organizations and procedures for test equipment acquisition and inventory management are described in Chapter 2; those for test equipment support (calibration and repair) are presented in Chapter 3. The acquisition and support procedures for TPSs are described separately in Chapter 4.

Appendix A shows the Army's charter for its Program Manager for TMDE. Appendices B, C, and D summarize the standard management approaches for support equipment and ATE acquisition that have been adopted by the Military Services. Appendix E describes the Navy's unique approach to support equipment selection, while Appendix F details the Navy's planned approach (not yet officially approved) to including operating and support costs for commercial test equipment in procurement contracts through the concept of life cycle warranties.

2. TEST EQUIPMENT ACQUISITION AND INVENTORY MANAGEMENT

This chapter describes the management structures, processes, and procedures in the Military Services for test equipment acquisition and inventory management. It focuses on the similarities and differences in the various management functions, including acquisition of new test equipment; procurement of common ETE; development of standard ATE; inventory management (planning, inventory control, and modernization); and planning for wartime requirements.

MANAGEMENT STRUCTURE

Within each of the Military Services, management of peculiar test equipment is the responsibility of the acquisition or life cycle manager of the supported weapons system, while the acquisition and life cycle management of common test equipment is the responsibility of a separate manager. The primary differences occur in the authority and control given to the common test equipment managers.

The Army has the tightest, most centralized management structure, with a single program manager for both acquisition and life cycle management of all common test equipment. This program manager reports to the Executive Director for TMDE, Office of the Deputy Commanding General for Materiel Readiness, Army Materiel Command (AMC), and possesses the requisite authority and control for effective management of common test equipment (see Appendix A).

The Marine Corps, on the other hand, separates the acquisition and life cycle management of common test equipment. The Support and Test Equipment Section, Materiel Division, Headquarters Marine Corps, is the centralized procurement manager for principal end items of common test equipment, excluding secondary items and low-cost end items; whereas the Marine Corps Logistics Base, Albany, Georgia, is the principal inventory or item manager of common test equipment after it enters the inventory. Moreover, the procurement manager has little influence or control over the selection of test equipment to be purchased for new weapons systems.

The Navy and Air Force management structures are between these two extremes. The Navy has a central manager for the acquisition and life cycle management of common test equipment – the Test and Monitoring Systems Group of the Life Cycle Engineering and Platform Integration Directorate, Naval Electronic Systems Command (NAVELEX). Navy-wide management responsibility of this group is limited to what the Navy refers to as "standard GPETE [general-purpose ETE]"; acquisition and life cycle management of nonstandard common test equipment, low-demand common test equipment, and peculiar test equipment are dispersed among various test equipment item managers in the Systems Commands. The contracting for common test equipment and day-to-day inventory management (item management) has been delegated by NAVELEX to the Ships Parts Control Center (SPCC), Mechanicsburg, Pennsylvania, a field activity of the Naval Supply Systems Command. The Navy's management structure is actually designed to foster standardization within each Systems Command, rather than Navy-wide. Each of the Systems Commands has a centralized test equipment manager responsible for test equipment requirements review and approval.

The Air Force has designated the San Antonio Air Logistics Center (ALC), Texas, as the central manager of common test equipment, but its responsibility is limited to test equipment classified as FSC 6625. (It is also the "system manager" for standard ATE.) The acquisition and life cycle management of other common test equipment is dispersed among support equipment system program offices in the Air Force Systems Command (AFSC) and various system and item managers in the ALCs. A small office at Air Force Logistics Command (AFLC) Headquarters coordinates all test equipment support.

The separation of management responsibilities for acquisition decisions and life cycle management of common test equipment in both the Navy and Air Force appear to be a weak link that has been avoided in the Army's centralized management structure. The effectiveness of the centralized manager of common test equipment in both the Navy and Air Force is further limited by their lack of influence on test equipment decisions made during the weapons system acquisition process. Neither has the type of authority that the Army has delegated to its program manager for TMDE.

ACQUISITION MANAGEMENT PROCESS

The overall management approach to the acquisition of test equipment is uniform among the Military Services because both the process and procedures have been standardized by the weapons system acquisition process. The LSA process is defined in a military standard[1] and the management procedures are described in a Joint Service regulation, "Standard Integrated Support Management System" (SISMS). A summary of the LSA process is provided in Appendix B, while an extract of SISMS is included as Appendix C.

The current version of MIL-STD-1388 represents a major improvement over the previous version (dated 15 October 1973) and is normally invoked (although tailored to the particular circumstances) in most acquisition programs. Both the Air Force and the Navy customarily apply SISMS for major acquisition programs, but the Army does so only when it is involved in a multi-Service acquisition program.

In addition to the LSA and SISMS, the Military Services use jointly developed guides for the acquisition of automatic testing capabilities (both built-in-test and off-line ATE). Those guides are summarized in Appendix D. A description of the acquisition management process as implemented by the Army, Navy, and Air Force follows.

Army

With the 1982 reorganization of its management of TMDE, the Army adopted a centralized system of acquisition approval and registration that is conducted by the Central TMDE Activity (CTA), Lexington Bluegrass Depot, Kentucky, under the authority of the Commanding General AMC as Department of the Army (DA) executive agent for TMDE. The CTA performs the Army-wide inventory management of TMDE used in the maintenance of equipment in the fielded Army, but this role is limited to the category of TMDE supported by Army TMDE support units [i.e., common TMDE

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[1]MIL-STD-1388-1A, "Logistic Support Analysis," 11 April 1983, and MIL-STD-1388-2A, "DoD Requirements for a Logistic Support Analysis Record," 20 July 1984 (Washington, D.C.: Department of Defense).

and selected items of peculiar TMDE subject to agreement by the U.S. Army TMDE Support Group (USATSG), Redstone Arsenal]. Its functions in support of this responsibility include the following:

- Conducting assessments of TMDE to identify problems in performance, supportability, or schedule.

- Maintaining the Army "Preferred Items List (PIL) for TMDE" (DA Pamphlet 700-21-1) as well as the "Army TMDE Register" (DA Pamphlet 700-20), which lists all common TMDE in the Army inventory or approved for Army use.

- Publishing the "Equipment Improvement Report and Maintenance Digest for TMDE" (Technical Bulletin 43-0001-61) as a means of disseminating information and lessons learned to Active and Reserve Component TMDE users.

- Developing and maintaining the Army's TMDE management information system, which is intended to provide a single source of information on TMDE inventory position, maintenance history, performance, and other characteristics.

All these functions fall under inventory management. One additional function of the CTA, and the primary reason why it is mentioned in this section on acquisition management, is its approval authority for most TMDE acquisitions in the Army. (Some TMDE, such as mechanical gages and certain items managed by the Army Intelligence and Security Command, are exempt and identified in Appendix B of Army Regulation 750-43, "Test, Measurement and Diagnostic Equipment," April 1984.) The TMDE selection and acquisition approval process is described below.[2]

Test equipment requirements are first identified in the LSA process. Normally, the contractor will document LSA results in the LSA record Data Sheet C (Maintenance Task Analysis) and then screen the various test equipment inventory lists in preparing LSA record Data Sheet E ("Support Equipment, Special Tools or Training Equipment Description and Justification"). Contracts typically require the following order of priority for test equipment selection:[3]

- DA Pamphlet 700-21-1

- DA Pamphlet 700-20

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[2]For a more detailed description and recent case examples of Army acquisition programs, the reader is referred to: Giordano Associates, Inc., LSA TMDE Requirements Analysis Study (Corona, California: Fleet Analysis Center, 30 September 1983).

[3]The list has been adopted, with some changes, from the TMDE selection criteria stated in the AN/TPQ-36 Firefinder radar contract.

- DA Supply Catalog
- Other Government/DoD inventory items as listed in:
  - Military Handbook (MIL-HDBK) -300 [U.S. Air Force (USAF)], "Technical Information File of Support Equipment"
  - Technical Order (T.O.) 33K-2-100 (Air Force), "Precision Measuring Equipment"
  - T.O. 33-1-1, 33-1-2, and 33-1-3 (Air Force), "Electronic Test Equipment Nomenclature Assignments, Government-Industry Data Exchange Program (GIDEP)"
  - MIL-STD-1364 (Navy), "Standard General Purpose Electronic Test Equipment"
  - Technical Manual (TM) 6625-15/1 (Marine Corps), "Electronic Nomenclature Assignments"
  - Hewlett-Packard and Tektronix Logistics Data Books
- Modification of existing military specifications test equipment
- Off-the-shelf commercial items
- Modification of commercial items
- Development of new test equipment to meet peculiar requirements.

Depending on the way the contract is worded and the contract data requirements list, the contractor-proposed test equipment may be documented in the LSA record or in the form of Ground Support Equipment Recommendation Data in accordance with a standard data item description, Data Item (DI) -S-6176. The ILS management team assigned to the program reviews this documentation with final approval or disapproval by the program manager based on adequacy of the justification and cost effectiveness of the proposed approach. Following approval by the program manager, the contractor prepares a functional description for any new items on the approved list of test equipment.

The program management office prepares a DA Form 4062-1-R ("TMDE Requirements Review") for each approved test equipment item (as well as a DA Form 4062-R, "TMDE Item Technical Description," for any new item), and this documentation is forwarded with a letter "clearance request for TMDE" to the CTA for approval and to the item manager for information. The item manager for most common ETE is located in Communications-Electronics Command (CECOM). The

requesting activity, i.e., program management office, may be located in any one of the other major subordinate commands of AMC. The item manager is responsible for entering the item in The Army Authorization Document System and for type classification or NSN assignment. The CTA, in coordination with the Program Manager for TMDE and the USATSG, approves or disapproves the selected test equipment items.

In the event of disapproval by the CTA, the requesting activity may submit additional justification data for reevaluation, with unresolved problems brought to the attention of the Executive Director for TMDE. Following that approval, the requesting activity or item manager initiates procurement of the approved item. For any new items, CTA updates the TMDE register with the information from DA Form 4062-R.

The Army PIL, which is updated annually, currently contains 137 items of common ETE. The TMDE Register is published in two parts, an index listing on paper and a Technical Description section on microfiche. The TMDE Register contains approximately 3,000 items, including calibration equipment and about 110 items of ATE. (A 1983 purge of the Register reduced the number of line items by about 40 percent.) The 3,000 items include both high-density items used by field maintenance units and low-density items used at research and development activities and depots. We stated previously that the Army's inventory of common ETE (FSC 6625) includes over 18,000 NSNs (Test Equipment Management, Logistics Management Institute, Task ML403, January 1985). The discrepancy is explained by noting that the TMDE Register is not an inventory listing (rather it is defined as a list of all common TMDE that have received acquisition approval in the past), that some items carry multiple NSNs, and that disposal of obsolete TMDE has not been policed. As a result, a precise count of the TMDE inventory (line items and density) is not available. The Army is now in the process of developing an automated TMDE inventory system and data base (common TMDE only), with the initial version scheduled for completion in late 1985. It is also implementing new regulations for turn-in of obsolete TMDE

Navy

Test equipment acquisition in the Navy is performed by numerous activities. In this section, we focus on the acquisition of test equipment in support of submarine/surface ship acquisition programs managed by the Naval Sea Systems Command (NAVSEA) and that in support of aircraft acquisition programs managed by the Naval Air Systems Command (NAVAIR). (Test equipment acquisition procedures for the Navy's strategic systems, for industrial activities and laboratories, and for the Marine Corps are different in various degrees.)

NAVSEA. Test equipment recommendations resulting from the contractor's LSA efforts are forwarded by the prime contractor (normally the lead shipyard) via the cognizant Supervisor of Shipbuilding, Conversion, and Repair to the ship acquisition program manager (PMS). As in the case of the Army, contractors are normally required to screen lists of existing test equipment in preparing their test equipment recommendations, with selection typically in the following order of priority for NAVSEA programs:

- MIL-STD-1364 (Navy), "Standard General Purpose Electronic Test Equipment" (current version F, March 1982). This document lists the Navy's preferred items of common ETE. It contains about 350 items. It is maintained and updated by NAVELEX every 3 years, with quarterly updates ("GPETE Status List With Reference Prices") published and distributed within the Navy.

- NAVSEA-0967-LP-008-9000, "Test Equipment Index to Shipboard Portable Electronic Test Equipment Requirements List (SPETERL)." This index lists all ETE (common and peculiar) in the NAVSEA inventory, organized by type of test equipment. Currently, it contains about 550 different types, including 140 nonstandard GPETE and the rest special-purpose test equipment (SPETE). It is maintained and updated by NAVSEA.

- Other Government/DoD inventory lists.

- Off-the-shelf commercial test equipment.

- Modifications to existing test equipment.

- Development of new peculiar test equipment.

After PMS review and approval, the test equipment recommendations are forwarded to the cognizant organization within NAVSEA (Weapons and Combat Systems Directorate, Test and Monitoring Systems Division, SEA-06C1) to validate the requirement and determine what activity

has management responsibility for each item. (SEA-06C1 is also responsible for reviewing and approving the shipboard test equipment allowance list.) The PMS is responsible for acquisition and management of most, but not all, SPETE requirements. The GPETE and selected SPETE requirements are forwarded with an approval request form to NAVELEX. The cognizant office within NAVELEX (ELEX-84) reviews the proposed test equipment, purchases the SPETE that is under its management, determines the proper classification (general purpose versus special purpose) of the remaining ETE, and reevaluates the need for any nonstandard GPETE (i.e., ETE classified as general purpose, but not included in MIL-STD-1364). (As an aside, the Naval Electronics System Engineering Activity, St. Inigoes, Maryland, not NAVELEX, provides the engineering support for ETE.) Based on its review, NAVELEX may decide to substitute standard items for nonstandard GPETE items specified in the approval request. All GPETE is purchased by NAVELEX using funds provided by the PMS. (If the program, however, involves a ship or weapons system modification instead of a new system, NAVELEX funds the GPETE.)

The actual mechanism for test equipment acquisition involves several field activities and fund transfers. SPETE purchased by the PMS is actually contracted for by SPCC; the latter may also become the inventory manager for those items depending on the PMS's delegation of responsibility. For ETE purchased by NAVELEX, funds are transferred to the NAVELEX Detachment Mechanicsburg, which then, in conjunction with NAVELEX Headquarters, prepares the documentation needed by SPCC for purchasing the item. SPCC performs the contracting and, in most cases, becomes the item manager.

NAVAIR. NAVAIR, like the Air Force, has adopted SISMS in managing the acquisition of test equipment. The process is based on contractor identification of test equipment requirements through the weapons system LSA effort and documentation of contractor-recommended solutions in the Support Equipment Recommendation Data (SERD). The SERD is a standard contractual data item prepared for each piece of support and test equipment. It includes a functional analysis,

recommended solution, and, for new test equipment, the necessary design and logistic support data. The contractor is normally required to use the following order of priority in selecting test equipment.

- Preferred items listed in NAVAIR PILs:
  - NAVAIR 16-1-525, "Avionics Preferred Common Support Equipment"
  - NAVAIR 19-1-127, "Non-Avionics Preferred Common Support Equipment"
- Existing peculiar test equipment, using the following data sources:
  - Engineering Data Retrieval System, a large data base maintained by the Naval Air Engineering Center (NAEC), Lakehurst, New Jersey
  - MIL-HDBK-300 (USAF) "Technical Information File of Support Equipment"
- Off-the-shelf commercial test equipment
- Modification of existing common or peculiar test equipment
- Development of new peculiar test equipment.

NAVAIR normally supports the contractor in the SERD development process by providing a resident support equipment expert from NAEC for liaison and data feedback from NAEC's data bases as required by the contractor.

NAEC screens and verifies all completed SERDs. It ensures that there is a valid test equipment requirement; it verifies that the SERD is complete; and it solicits comments on selected SERDs from appropriate activities (e.g., the cognizant Naval Air Rework Facility would normally review any depot-level test equipment recommendations). It also reevaluates any new test equipment recommendations by screening the PILs and Engineering Data Retrieval System to determine whether existing test equipment could satisfy the testing requirements. One of the tools used by NAEC is a formalized support equipment selection analysis process that is described in Appendix E. If it finds that new test equipment is indeed necessary, it performs a technical evaluation of the contractor's recommended items. Once its review is completed, NAEC prepares a SERD disposition letter, approving, modifying, or disapproving the contractor's SERD.

NAEC operates under the direction of NAVAIR's centralized support equipment manager, the Systems and Engineering Group, Support Equipment Division (AIR-552), which is

responsible for managing all aspects of naval aviation support equipment. AIR-552 normally delegates SERD approval for all nonmajor items to NAEC. Its primary emphasis is on budget items; it budgets support equipment requirements for the aircraft program manager and it monitors the funds allocated for peculiar support equipment as well as funds allocated for NAVAIR's common support equipment. NAEC coordinates funding requirements with AIR-552. (In contrast to the other Military Services, AIR-552 is the ultimate SERD approval authority, not the weapons system program manager.)

The approved SERD is forwarded to the Aviation Supply Office and the Naval Air Technical Services Facility. The Aviation Supply Office, the inventory control point for aviation items and associated peculiar support equipment, computes allowance requirements for support equipment, provisions for spare and repair parts, and coordinates with other inventory managers to ensure availability of items that are not under its control. Standard GPETE is not under the control of the Aviation Supply Office; it is managed by NAVELEX, with SPCC performing the day-to-day management control. The Naval Air Technical Services Facility is responsible for monitoring the preparation and delivery of technical manuals, maintenance requirements cards, calibration measurement requirements summaries, and calibration procedures. Calibration measurement requirements summaries and calibration procedures are also reviewed and approved by the Naval Aviation Logistics Center, which is responsible for ensuring that adequate calibration equipment will be available to satisfy the test equipment calibration requirements.

Peculiar ETE is acquired generally by NAVAIR directly via the aircraft contract, and its development is monitored by NAEC. Common ETE is acquired by forwarding funded requisitions to SPCC, which then purchases the equipment.

The above outline illustrates that the "centralized manager" for standard GPETE (ELEX-84) has only limited control over NAVAIR's selection of test equipment. MIL-STD-1364 is not referenced in SISMS nor in NAVAIR's description of its test equipment acquisition management process. SISMS emphasizes MIL-HDBK-300 as the single data source for standardization of support equipment. Some MIL-STD-1364 items may be contained in MIL-HDBK-300, many are not.

Air Force

The Air Force's organizational structure for test equipment acquisition management is somewhat complex. AFSC is responsible for the acquisition of new aircraft systems and all new peculiar support equipment, while AFLC is responsible for supplying the prime contractor with all required common support equipment as Government-furnished equipment and for managing all follow-on logistic support. However, the support equipment selection and approval process involves a number of organizations with different responsibilities. While the various product divisions of AFSC follow different procedures, the description that follows is limited to the largest product division in AFSC, the Aeronautical Systems Division.

Contractual guidance on the preparation of SERDs for a new weapons system normally specifies the following order of priority for test equipment selection:

- Equipment defined by existing Government specifications or modifications thereof
- Off-the-shelf commercial test equipment already in the Government inventory
- Other off-the-shelf commercial or modified equipment
- Development of new peculiar test equipment.

The contractor is required to screen MIL-HDBK-300 as the primary data source for existing support equipment (the first two items above). Another data source that is frequently used for ETE in the Air Force inventory is T. 33K-1-100, "Precision Measurement Equipment Interval, Labor Estimate, Calibration and Repair Technical Order Reference Guide and Work Unit Code Manual." MIL-HDBK-300 is maintained by AFLC's Cataloging and Standardization Office, Battle Creek, Michigan, and lists support equipment for all aircraft and missile systems in the DoD inventory. The equipment included on that list has a unit cost of at least $1,000 or a total procurement value of at least $100,000 regardless of unit cost. (The Cataloging and Standardization Office has had serious problems keeping this data base up to date; furthermore, the data base is difficult to use because it is published on microfiche.) The T.O. 33K-1-100 is maintained by San Antonio ALC, the item manager of all common ETE (FSC 6625) in the Air Force.

Since the SERDs are reviewed by numerous organizations in the Air Force, the allotted time of 60 days is often insufficient to complete the review-and-approval cycle. The contractor submits SERDs normally to two organizations, the weapons system program manager or system program office (SPO), and the end-item system manager (located at an ALC).

Each weapons system SPO is supported by a team of logistics experts, on a matrix organization basis, from the Air Force Acquisition Logistics Center, an organization that reports both to AFSC and AFLC. The team, headed by the Deputy Program Manager for Logistics, plans, reviews, and manages all logistics areas of a weapons system acquisition program, including support equipment acquisition logistics. In addition, the support equipment system program office (SESPO) assigns support equipment managers to the weapons system SPO for the integration of financial management of support equipment acquisition. The SESPO is a relatively recent organization designed to improve the management of support equipment in the acquisition process, integrate all research and development of support equipment, and increase commonality (cross-system application) of support equipment. Both the support equipment manager and SESPO review the SERD and report their findings or recommendations to the weapons system SPO through the Deputy Program Manager for Logistics.

Within AFLC, the end-item system manager distributes the SERD to the following organizations for review:

- The user of the weapons system, such as Tactical Air Command.
- The ALCs that will be the item managers of the support equipment. Their responsibility is to conduct an engineering and technical review to determine whether existing support equipment or modifications thereof (or, alternatively, commercial off-the-shelf test equipment) could satisfy the requirement rather than contractor-proposed new peculiar equipment.
- The ALCs that will provide depot-level maintenance of the support equipment. (The assignment of depot-level maintenance responsibility for each subsystem may not necessarily coincide with that of the item manager.)
- The Aerospace Guidance and Metrology Center (AGMC), which is responsible for reviewing the Calibration Measurements Requirements Summary of new test equipment, evaluating the need for new calibration equipment, and developing calibration procedures once the SERD is approved.

- Cataloging and Standardization Office.

After these organizations review the SERD, their recommendations are accumulated by the end-item system manager and reported to the Aeronautical Systems Division weapons system SPO, who has the final approval authority on the selection of support equipment. Once the decision is made, items are either acquired through the weapons system contract as contractor-furnished equipment or through the cognizant ALC as Government-furnished equipment. Funding of the latter is provided by AFLC.

It may be of interest to draw a comparison between the acquisition management processes of the Air Force and NAVAIR. The NAVAIR Support Equipment Division (AIR-552) is comparable to the Air Force Aeronautical Systems Division SESPO in that it provides centralized management of all support equipment. It is, however, different in two respects: AIR-552, not the aircraft program manager, has the final approval authority for SERDs; furthermore, it is ultimately responsible for life cycle management of fielded support equipment – a responsibility that is dispersed among various ALCs in the Air Force. SESPO, as an AFSC organization, is not similarly involved.

Observations

In practice, a number of weak points in the test equipment selection-and-approval process are commonly well recognized. They include:

- The process is invariably started late in the weapons system development cycle, which impedes tradeoffs between design characteristics and support equipment commonality. As a result, opportunities for more standardization of test equipment are lost.

- The screening of inventory lists by the contractor in preparing test equipment recommendations is impeded because the lists are incomplete, out-of-date, and difficult to access. Furthermore, the process is not policed.

- The review anc . erification of the contractor's recommendations by the DoD is often limited by scarce resources (experienced personnel and schedule).

A perhaps less obvious weakness is that the entire process, by its very nature, tends to be suboptimal because it deals with test requirements in a piecemeal fashion. This affects both the test equipment required to support a single weapons system and the test equipment required by a maintenance unit supporting multiple weapons systems.

With regard to the first, a single weapons system may involve hundreds, if not thousands, of SERDs. These documents are prepared and reviewed in sequence, not all at the same time. While all the SERDs may be correct, the composite may not be optimal. The key factors in this process appear to be the contractor's incentive, which often is counter to DoD's, and the small size of the DoD's review team.

With regard to the second, both the Navy and Air Force have an effective process for developing a test equipment allowance list (minimizing the variety and density of test equipment) for a ship or aircraft squadron, but the Army does not have a similar process for its maintenance units (especially at the intermediate level). Test equipment requirements for each new system are added incrementally to whatever test equipment the supporting maintenance units already are authorized in their Tables of Organization and Equipment. The Army's Program Manager for TMDE has recognized this deficiency and recently instituted a new approach to test equipment requirements determination.

It is noteworthy that the Military Services use different lists in screening the DoD inventory of test equipment and apply different criteria in selecting candidate items. To illustrate, the Army and Air Force prefer modifying existing military specification equipment over procuring commercial off-the-shelf test equipment; in contrast, the Navy (both NAVSEA and NAVAIR) gives priority to commercial off-the-shelf equipment over modification of existing common or peculiar test equipment

An additional comment: MIL-STD-680A, "Contractor Standardization Program Requirements," 2 October 1981, is approved for use by all DoD agencies and, if invoked in the contract, requires contractors to exercise standardization discipline throughout each weapons system acquisition phase. With respect to tools and support equipment, it requires the same controls as applied to system components and equipment.

> Commonality shall be stressed and multi-application tools and support equipment shall be used wherever possible. The contractor shall review the tools and support equipment currently in the Government inventory for application to the contract. On the basis of such review, the contractor

shall use current Government tools and support equipment in preference to the introduction of new tools and support equipment wherever possible.

However, a Navy-peculiar appendix to the standard enumerates the "design selection lists" for use in the contractor's standardization program, including NAVSHIPS-0969-019-7000, "Electrical Test Equipment Application Guide" for ETE; MIL-HDBK-300, "Technical Information File of Support Equipment" for aerospace ground support equipment; MIL-STD-1364, "Standard General Purpose Electronic Test Equipment"; NAVAIR 16-1-525, "Avionics Preferred Common Support Equipment"; and NAVAIR 19-1-527, "Non-Avionics Preferred Common Support Equipment."

A final comment pertains to the feasibility of changing the acquisition process by constraining weapons system design to be supportable with a given list of standard test equipment. Such a requirement has never been imposed except for standard ATE. Several acquisition programs have specified that the system be supportable with a given ATE, but that approach has not been very successful. Many acquisition programs, especially those in the Army, include a requirement to minimize the need for test equipment at the organizational level. Such requirements can be successful in directing the design toward comprehensive built-in test. However, even when contract requirements are clearly specified, success is not guaranteed. The best example, probably, is the UH-60 Black Hawk program, where the specific tools used by organizational maintainers were nailed to the wall in the contractor's design shop as a visible reminder for the design engineers to constrain their design to be supportable with those tools. This innovative and highly effective approach was largely successful, even though it became obvious once the UH-60 was fielded, that a special test set was necessary to cope with the electronic control unit assembly of the turbine engine.

The UH-60 example, however, does illustrate that support equipment commonality is achievable if it receives sufficient management attention at an early stage when it counts. Proper implementation of "front-end analysis," as prescribed in the 1983 revision of MIL-STD-1388, may help to achieve better tradeoffs in the future between weapons system design characteristics and support equipment commonality.

PROCUREMENT OF COMMON ETE

The result of the acquisition management process described above is the development of peculiar test equipment and/or the procurement of common test equipment. With regard to new common ETE, the trend is toward the procurement of commercial off-the-shelf test equipment for which the Military Services (with the exception of the Marine Corps) have adopted a similar procurement approach, known as "bid sample testing."

Bid sample testing is a two-step competitive procurement method in which the first step entails a technical evaluation of the candidate products and the second step consists of soliciting bids from those vendors who passed the evaluation. This method permits the DoD to meet its need for a product at the lowest cost when the characteristics of that product cannot be adequately described in a detailed specification or purchase description.

The Federal Acquisition Regulation (FAR) is clear about the Government's policy favoring commercial products whenever possible:

> In a manner consistent with statutes, Executive Order, and governing regulations regarding maximum competition, agencies shall acquire commercial products and use commercial distribution systems whenever these products or distribution systems adequately satisfy the Government's needs. [FAR, section 11.002]

The FAR is also clear about the circumstances under which bid sample testing is appropriate:

> (1) Bidders shall not be required to furnish bid samples unless there are characteristics of the product that cannot be described adequately in the specification or purchase description.
>
> (2) Bid samples will be used only to determine the responsiveness of the bid and will not be used to determine a bidder's ability to produce the required items.
>
> (3) Bid samples may be examined for any required characteristic, whether or not such characteristic is adequately described in the specification, if listed in [the invitation for bid].
>
> (4) Bids will be rejected as nonresponsive if the sample fails to conform to each of the characteristics listed in the invitation. [FAR, paragraph 14.202-4(b)]

All Military Services use MIL-T-28800C, "Test Equipment For Use with Electrical and Electronic Equipment, General Specification for"; 23 December 1981, in preparing their purchase description. That document also specifies the tests and inspections for quality assurance of the candidate products. A brief description of the general specification and the procedures of the Military Services follows.

General Specification

Although MIL-T-28800C describes the general requirements for test equipment, it is not suitable to be invoked in a contract without the use of a detailed specification, such as a military specification, purchase description, or a "brand name or equal" purchase description.

It categorizes test equipment by type (design/construction), class (environmental requirements), style (type of enclosure), and color. There are three types (Type I is designated for military use, Type II is modified commercial off-the-shelf equipment, and Type III is commercial off-the-shelf); five classes (with different environmental conditions such as temperature, humidity, and shock resistance); nine styles (ranging from extremely rugged cases to rack-mount cases and console cabinets); and eleven colors. MIL-T-28800C describes the requirements for safety, parts and materiels, design and construction, electrical power sources and connections, mechanical stability, enclosures, marking, environmental conditions, reliability, maintainability, and interchangeability. As an example, for Type III reliability, it states that unless a mean time between failures (MTBF) is specified in the detailed specification, the upper test MTBF for continuous and intermittent operation shall be 1,500 hours under the environmental conditions specified for the equipment, when tested in accordance with MIL-STD-781, test plan IIIC. Similarly, for Type III maintainability, it states that, unless otherwise required in the detailed specification, equipment design shall permit isolation of faults down to the lowest discrete component with the maintenance provisions furnished as part of the equipment. A maintainability demonstration, if required in the contract, shall be performed in accordance with MIL-STD-471, with a mean corrective maintenance time of 90 minutes, maximum tolerable mean corrective maintenance time of 115 minutes, and maximum corrective maintenance time not to exceed 270 minutes. With respect to calibration requirements, it states that the

calibration interval, unless otherwise specified in the detailed specification, shall be 9 months, based on an equipment operation time of 1,500 hours.

MIL-T-28800C also lists the tests or quality assurance provisions for the three types of inspection conducted by suppliers and/or the Government: first article inspection, bid sample inspection, or quality conformance inspection. The tests or inspections are categorized into six groups:

- Group A. Preoperational inspection (materials, workmanship, and safety characteristics, including random vibration and temperature cycling tests); Level A performance test (exercising all functions and modes of operation); open circuit voltage test; and leakage current test

- Group B. Level B performance test in accordance with approved equipment test procedures or the detailed specifications

- Group C. Environment tests, including temperature and humidity, altitude, vibration, shock, water resistance, and electrical power tests (power consumption, voltage and frequency variation, and transients)

- Group D. Environmental tests, including fungus resistance, salt atmosphere, explosive atmosphere, sand and dust, electromagnetic interference, and magnetic environment tests

- Group E. Miscellaneous tests and inspections, including maintainability, acoustic noise, dimensions and weight, mechanical stability, equipment emanations, front panel markings, and packaging

- Group F. Reliability tests.

For bid sample testing, the specification states that, unless otherwise required in the solicitation, the bid sample shall consist of two equipments with accessories and instruction manuals and "clear and concise" rationale showing how the reliability and maintainability (R&M) characteristics of the equipment comply with the requirements of the solicitation (hereafter referred to as the "R&M rationale"). It further specifies that the two bid sample equipments will be subjected first to the Group A inspections and then to the Group B tests (if required) if both pass the Group A inspections. Next, one bid sample equipment will be subjected to Group C and Group D tests, and, finally, both equipments will be subjected to Group E tests. Importantly, the specification stipulates that, unless otherwise specified in the solicitation, maintainability and reliability testing will not be performed on bid samples.

Military Service Procedures

Army. The Project Manager for TMDE Modernization (PM, TEMOD), as the acquisition manager for new common ETE, and CECOM, as the item manager of the Army's common ETE, have used the competitive bid sample approach to procure commercial off-the-shelf test equipment since 1981. The Army issues a letter request for bid samples with a purchase description specifying the functional performance requirements and identifying the "facility of use" characteristics (adopted from MIL-T-28800C) that will be evaluated in the test. The Army usually requires a sample of three instruments: one for performance testing (with a maximum of three failures allowed) and two for "facility of use" testing. The facility of use testing, conducted by several groups, focuses on eight characteristics: safety, workmanship, human factors, construction/design, application compatibility, tester portability, ease of calibration, and maintainability. Evaluation and test reports are reviewed by CECOM and PM, TEMOD personnel, with final approval authority by PM, TEMOD.

Vendors that pass the bid sample test receive an invitation for bid. Bids are evaluated on the basis of three cost elements: (1) hardware (unit cost and initial provisioning, which are priced separately by the bidder); (2) documentation (separately priced in the bid); and (3) initial training (if required and separately priced). The lowest-cost bidder receives the contract.

In 1983, the Army examined the life cycle costs of four items of common ETE to identify cost categories that have a significant contribution to life cycle cost, differentiate between bidders, and are verifiable in bid sample testing. It found that four cost elements met all three conditions: test equipment hardware cost (57 to 69 percent of life cycle cost), maintenance and calibration labor cost (4 to 17 percent), consumables (8 to 11 percent), and initial provisioning of spare parts (5 to 7 percent). Based on these findings, the Army decided to include an estimate of maintenance and calibration labor cost in its bid evaluation and to improve its estimate of initial provisioning costs (rather than relying on vendor estimates).

In fiscal year 1985 (FY85), the Army began using a simplified cost model to estimate ownership costs from the following input data (with the first four parameters specified by the Army for a particular procurement):

- Life cycle (years of operation)
- Quantity (number of items required)
- Utilization (number of operating hours per year)
- Hourly labor wage (depot-level technicians)
- Calibration interval (vendor specified)
- MTBF (vendor specified)
- Mean time to repair (MTTR).

The solicitation package further includes a minimum acceptable MTBF and a maximum acceptable MTTR. In the bid sample testing, each bidder's claimed MTTR is verified through a maintenance demonstration. The claimed MTBF is verified only for the winning bidder through a reliability test. This life cycle costing approach was for the first time applied in 1985 in the procurement of a (commercial) distortion analyzer. Among the three bidders submitting bid samples, some of the above factors showed a wide range. The contract was awarded to the bidder with lowest projected life cycle cost. Of the losing bidders, one had the lowest unit cost, the other had the highest reliability. The Army is planning to further refine this procedure, making the demonstrations a separately priced option that may not be exercised when those factors (calibration, reliability, and maintainability) are close and do not influence contract award.

Navy. NAVELEX, as the centralized manager of Navy common standard ETE, has used the competitive bid sample approach since 1977. Bid samples are required for all competitive procurements of common test equipment by NAVELEX (about 75 percent of all its test equipment funds). NAVELEX prepares a tailored purchase description using MIL-T-28800C, the specific measurement requirements, and engineering judgment, with the "salient characteristics" normally expressed as a "brand name or equal" specification. It requests two samples per item bid for testing.

Tests are conducted and evaluated at one of the two Navy laboratories in accordance with the detailed purchase description and MIL-T-28800C. Final decisions on the test evaluations are made by NAVELEX. The second step of the procurement (invitation for bid and contract award) is performed by SPCC. The contract is awarded on the basis of lowest unit cost. NAVELEX is considering some type of life cycle costing approach and is also planning to put increased emphasis on the quality of technical manuals in the bid evaluation process.

NAVELEX has experimented with life cycle costing approaches, but it has not been satisfied with the results. It does not believe that the Army's approach to detailed life cycle cost analysis in procuring common ETE is a cost-effective endeavor, except for very large procurement programs. It finds the Army's procedure complex and partly subjective; particularly, it notes that the projected service life (a very subjective and arbitrary estimate) can have a serious skewing effect on any life cycle costing approach. Instead, NAVELEX has recently developed an innovative approach that, in essence, levies the life cycle costing problem on the vendor. The approach rolls the support costs into the procurement contract through the concept of a life cycle warranty or service contract. For details on this approach, which has not yet been approved as official Navy policy, refer to Appendix F. NAVELEX plans to conduct a pilot application of this approach in 1986. Reactions to the concept have been mixed: those from large test equipment manufacturers have been most favorable, those from small manufacturers and small business advocates have been negative.

NAVAIR has recently experimented with life cycle cost models in the replacement of commercial test equipment embedded in ATE. For example, the AN/AWM-23 – which is a hybrid, special-purpose ATE comprising five stations for testing of line replaceable units from the AN/AWG-9 radar on the F-14A aircraft – is being modernized, primarily because the commercial test equipment has become obsolete and unsupportable. NAVAIR is using a competitive procurement based on technical, supportability, and life cycle cost factors to replace these items.

Marine Corps. The Marine Corps has never used bid sample testing as a procurement procedure for commercial ETE. Instead, it issues a detailed specification (performance requirements and "salient characteristics" from MIL-T-28800C) with a request for quotation and awards a contract

on the basis of lowest price. (Most of its peculiar test equipment is acquired in the course of weapons system acquisition programs managed by another Military Service, although the number of Marine Corps programs has grown in recent years.) In special cases, such as for automated testers, it has conducted some first article test and evaluation. To meet emergency requirements, it may purchase from the General Services Administration schedule. Apart from these exceptions, the Marine Corps purchases through open bids without bid sample testing, relying on vendor claims of meeting the detailed specifications and awarding the contract to the lowest bidder.

Air Force. San Antonio ALC adopted the competitive bid sample approach in the late 1970's as its standard procedure for the procurement of commercial off-the-shelf ETE (FSC 6625). Project engineers prepare purchase descriptions for needed test equipment and, when funds are available, item managers write purchase requests that result in the contracting officer issuing solicitations for bid samples. Vendors have 45 calendar days to submit a bid sample package that normally consists of two instruments, the manufacturer's operation and maintenance manual, acceptance test procedures, and the R&M rationale. An Air Force test laboratory receives the bid sample package, performs the inspections and tests in accordance with MIL-T-28800C, and writes the test report. Each bid sample package is allowed two failures. After the first failure, the tests assigned to the failed instrument are reassigned to the other instrument. After the second failure, testing stops and the vendor is called in to repair one of the two failed instruments. Testing then resumes on the repaired instrument. A third failure during testing disqualifies the bid sample.

The project engineer evaluates the laboratory's test report and either approves or disapproves the bid sample package. The entire process is completed within 60 days from receipt of the package. The contracting officer issues an invitation for bid to those vendors who passed the test, and the contract is awarded to the lowest bidder.

Observations

The overall approach to the competitive procurement of common ETE is similar among the Military Services, but the detailed procedures are different. All, except the Marine Corps, are trying to improve their procedures to include evaluation of the cost of ownership. A clear potential

exists for cost savings by procuring on the basis of minimum life cycle cost instead of procurement cost. The Military Services need to proceed with collecting and analyzing cost data to make life cycle costing feasible. Similar data are needed also to determine the most cost-effective maintenance concept for new test equipment.

Furthermore, the opportunity for significant cost savings through Joint Service procurement of common ETE (elimination of duplicative testing, quantity discounts, lower logistic support costs) is impeded by the lack of Joint Service standardization of common ETE and common evaluation procedures. As a result, Joint Service buys are rare.

The life cycle warranty concept proposed by NAVELEX is easily the most exciting idea that has surfaced in the test equipment community in recent years. It would alleviate most of the problems encountered in commercial test equipment procurement and support; and it should result in substantial life cycle cost savings. Some refinements in the proposed approach may be desirable, however, to protect against emergency and wartime support requirements.

DEVELOPMENT OF STANDARD ATE

Confronted with escalating costs for ATE, each of the Military Services has embarked on an ATE standardization program. Those programs are described in this section.

Air Force

In the tactical Air Force, field-level ATE is primarily found within the avionics intermediate shop (AIS). The AIS, normally organic to the wing it supports, provides intermediate maintenance, i.e., checkout and repair of line replaceable units (LRUs), which are assemblies (boxes) removed from the aircraft by organizational maintenance. [Checkout and repair of shop replaceable units (SRUs), which are circuit cards and electronic modules such as power supplies, are depot maintenance functions in the Air Force.] The Air Force plans to deploy Tactical Air Wings to two main operating bases in wartime. Then, the AIS will be split into two parts, one supporting a single squadron at one base and the second supporting the other two squadrons at the second base. Even within the tactical air community, there are significant differences between U.S. Air Forces in Europe (USAFE) and Pacific Air Forces (PACAF) with regard to intermediate maintenance. In

PACAF, intermediate maintenance is consolidated at the Pacific Logistics Support Center, Kadena Air Base, Okinawa, Japan. As a result, AISs are no longer organic to the wings and squadrons as they are in USAFE. Moreover, since 1984, PACAF has moved depot-level maintenance of avionics forward by establishing the Support Center Pacific, collocated with the Pacific Logistics Support Center. This is currently the only field location in the Air Force where both LRUs and SRUs are tested on ATE.

The operational environment and mission requirements are characterized by the AIS. Each AIS supports a particular type of aircraft and operates from a large air base with little constraints on space or other support resources (e.g., power, air conditioning), although for deployment purposes the ATE must be air-transportable.

To control ATE acquisition and support costs, the Air Force needed an approach to ATE standardization that would permit: (1) tailoring the ATE to the specific items supported by each AIS; (2) standardizing the ATE building blocks both across different AISs and across different maintenance levels (intermediate and depot); (3) utilizing nonmilitarized, commercial test equipment; and (4) enhancing ATE capabilities to support rapid avionics technology upgrades without major redesign of ATE hardware and software. The modular automatic test equipment (MATE) program is designed to accomplish each of these objectives. The MATE program is based on a standard ATE architecture, standard interfaces, and software standards, without actually standardizing the ATE hardware components (as long as they are MATE-qualified by the Air Force).

MATE was developed by a separate program office in AFSC, with life cycle management responsibility by San Antonio ALC, which also operates the MATE Qualification Center. The program completed full-scale development this year after a thorough operational test and evaluation of MATE applications at both intermediate maintenance (the intermediate automatic test set for the A-10 inertial navigation system) and depot maintenance (depot automatic test system for avionics for the testing of SRUs from a variety of aircraft).

Navy

The operational environment and mission requirements for ATE in support of naval air and surface combat systems are different from those of the Air Force. (Attack submarines have no off-line ATE aboard.) Aboard the aircraft carrier, the Aircraft Intermediate Maintenance Department provides intermediate maintenance to all deployed air squadrons and detachments. Its avionics branch employs a wide variety of ATE to perform both LRU (in Navy terminology, weapon replaceable assemblies or WRAs) and SRU (shop replaceable assemblies or SRAs) checkout, fault isolation, and repair. The workload aboard each carrier, however, is similar. The operational environment also differs from that for the Air Force's AIS in that space is very cramped and conditions are less benign (constant vibration, unreliable power and air conditioning).

Although the Navy, as an interim measure to stem ATE proliferation, already had adopted a standard family of ATE, NAVAIR's Consolidated Support System program was established in 1980 as a long-range solution with the objective of maximizing throughput capability within constrained space by using a flexible system architecture with standardized ATE hardware and software modules. Design concepts include integrating the ATE with automated information tools (maintenance history, job shop scheduling) to increase the effective use of the ATE.

The Consolidated Support System program completed the problem definition phase in August 1981 and systems definition phase in August 1983. Following a program review by the Secretary of the Navy in January 1985, the program scope was expanded to include the intermediate- and depot-level requirements of all Systems Commands, and the program name was changed to Consolidated Automated Support System (CASS). The program, previously managed by AIR-552, is now managed by a separate NAVAIR program office (APC-206), and is in full-scale development with contracts awarded in September 1985.

Aboard surface combatants, combat systems maintenance was performed without off-line ATE until recently. Maintenance policy was (and still is) shipboard replacement of the lowest replaceable unit (circuit cards and other electronic modules) and off-ship repair of that unit, usually at a depot. Surface ship combat systems were designed accordingly, relying on built-in test to guide

the technician toward the faulty unit and requiring manual troubleshooting, using common ETE, to fault isolate within ambiguity groups. Because of limitations of built-in test and limited experience and training of Navy technicians, this policy resulted in excessive removals and replacements of good modules (60 to 70 percent of the digital circuit cards received at depots for repair showed no evidence of failure), depletion of the supply system, and combat systems frequently down for lengthy periods awaiting parts and maintenance.[4] To solve this problem, NAVSEA determined that it needed to place small, portable ATE aboard surface combatants to permit testing of circuit cards for two purposes: (1) to stop evacuating good circuit cards to depots by screening them (go/no-go testing), and (2) to fault isolate (diagnostic testing) and repair circuit cards when cost effective. Under the Support and Test Equipment Engineering Program, digital circuit card testers have been installed aboard major surface combatants (cruisers/destroyers) as well as at intermediate maintenance facilities (tenders and shore intermediate maintenance activities). The ATE selected for this purpose by NAVSEA, in coordination with NAVELEX, was the AN/USM-465, a modification of the commercial off-the-shelf GENRAD-2225. This ATE is also used in the Army and Marine Corps for the same purposes. A successor to the AN/USM-465, with expanded capabilities, is under consideration and it may be acquired sometime in the future under the CASS umbrella program.

Army

Chronologically, the Army's need for field-level ATE was more recent than that of the Air Force and Navy. (For that reason, we are describing the Military Services' ATE programs in a sequence other than seniority.) In 1971, CECOM procured the first prototype of the Electronics Quality Assurance Test Equipment (EQUATE). The EQUATE [type-designated AN/USM-410(V)] was an integration of commercial off-the-shelf equipment into a general-purpose ATE system for fixed-plant installation. (Its testing capabilities were primarily based on meeting a depot testing

[4]For a detailed description of maintenance performance problems and contributing causes in the Navy, see F. Nauta, Alleviating Fleet Maintenance Problems Through Maintenance Training and Aiding Research, Technical Report (Orlando, Florida: Naval Training Equipment Center, May 1985).

requirement for radio end items and subassemblies.) After several iterations, the required operational capability (ROC) for General Support-Automated Test Support Systems was approved in March 1979. It identified the AN/USM-410(V) as a core system for general-support-level ATE, to be augmented as needed for the supported weapons systems and to be deployed in vans to provide environmental conditioning of the commercial equipment. Subsequently, AMC Headquarters decided in December 1979 to adopt the AN/USM-410(V) as the single Army standard ATE for general support and depot maintenance. It issued implementation instructions in June 1980, outlining the ground rules for determining whether or not system-peculiar ATE, under development or planned, should be terminated in favor of the AN/USM-410(V). Since that time, 14 major weapons system programs, including Patriot, have received waivers from using the AN/USM-410(V).

The van-mounted field configuration of the AN/USM-410(V), the Electronic Test Facility (ETF) (OQ-290), is equipped with the AN/USM-465 digital card tester and common manual TMDE. It is deployed in combination with the Equipment Repair Facility (ERF), OA-8991, which houses a countertop workbench with four repair stations, an oven for conformal coating after repair, and a quality assurance station with microscope. Each of the two vans is a 35-foot, 8-wheel, 10-ton capacity semitrailer that can be towed across unimproved roads with a maximum speed of 5 miles per hour but is neither transportable by rail (the AN/USM-410(V) does not have the required shock resistance) nor by helicopter (the AN/USM-410(V) is too heavy). The whole configuration, ERF plus ETF, nomenclature AN/MSM-105(V)1, with the requisite trailer-mounted electric power generator is air transportable but represents a full load for the C-5A. In other versions of the AN/MSM-105, such as the AN/MSM-105(V)2 for the AH-64 attack helicopter, the ETF is augmented with system-peculiar ATE and housed in more than one van, although the ERF remains the same.[5]

[5]A more detailed chronology of the AN/USM-410(V), its operational characteristics, and the augmented version AN/MSM-105(V)2 is provided in Frans Nauta, AH-64 Automatic Test Equipment Requirements, Working Note ML213-1 (Bethesda, Maryland: Logistics Management Institute, November 1982) (AD A122879).

At the end of FY84, the Army had on hand or under contract 142 AN/USM-410(V)'s, including 35 planned for deployment at general support (now intermediate rear), with the rest installed at Army depots (plus one at Fort Gordon, Georgia, for technical training) and contractors (primarily for TPS development). An additional 46 were planned for procurement from FY85 through FY88, for a total inventory of 188. These numbers are under review, however, because the AN/MSM-105 was planned for use at intermediate-forward maintenance to support some systems (e.g., DIVAD and AH-64 division level), but such usage is clearly not suitable. Instead, the intermediate forward test equipment (IFTE), now in development, may be used at that location. Because some of the equipment has become obsolete in the meantime (e.g., computers and peripherals), several engineering changes have been approved over the years. The Army plans to rely on the AN/USM-410(V) through the late 1990's.

The Army has had additional problems with its standardization plans for ATE at the direct support level, now called intermediate forward. The Army's need at this maintenance level is completely different from that of the Air Force or Navy. Intermediate-forward maintenance units must support a wide variety of different weapons and communications systems in adverse terrain under highly mobile conditions. Without proliferating peculiar ATE, this maintenance requirement translates into a standard, modular, bus-structured architecture that can be tailored or reconfigured to the supported commodity such that each ATE system will be compact enough to be housed in a truck-mounted shelter ($2\frac{1}{2}$- to 5-ton tactical truck) with enough space left for stocking interface devices and test program tapes (needed for testing the supported LRUs) and SRUs (needed for LRU repairs). This summarizes the operational requirement for the "base station test facility" (BSTF), which is one of the products of the IFTE program. [The proposed ROC, April 1980, includes additional required capabilities such as (1) screening of SRUs in addition to testing of LRUs, (2) meeting new test requirements through open-ended extensions of test capabilities with minimum development effort, (3) possessing self-test and self-alignment capabilities, etc.]

The IFTE program includes three more products. One is the conceptual development of an "electro-optical test facility." The second is a "contact test set" (CTS), which is a portable tester for

on-line testing, supplementing the weapons system built-in test and facilitating fault isolation to the removable LRU. The third product is software, including system software, support software, and application test programs for the planned prototype demonstrations. The first phase of the IFTE program was conducted from June through December 1983, with five contractors participating. Secretary of the Army review prior to transitioning to full-scale engineering development occurred in December 1984. A full-scale engineering development contract was awarded in September 1985. The contractor will build two prototypes, tailor the ATE to two selected weapons systems, demonstrate the capabilities of the ATE, and define the commodity-oriented ATE configurations. Prototypes are scheduled to be available for evaluation in late 1988, with production to start in late 1989, and first unit equipped in mid-1990. One of the unanswered questions at the present time is to what extent the equipment of the "base shop test station" (i.e., the actual ATE system with up to two per truck-mounted BSTF) will be commercial or militarized. The ROC is neutral on this topic (although it sets minimum R&M requirements), while the Statement of Work for Phase I required tradeoff studies on this topic. (In contrast, the ROC requires the CTS to be fully militarized.)

The past uncertainty and delays with the IFTE program have encouraged development and fielding of a variety of ATE to support weapons systems fielded since the late 1970's – ATE that may not be compatible with the future IFTE. For example, the ATE used in support of the M1 tank and the M2/M3 Fighting Vehicle Systems (FVS) provides a good illustration. At the organizational level, the M1 is supported by the simplified test equipment (STE)-M1, later modified to the STE-M1/FVS to provide commonality with the STE for the M2/M3. It provides 46 test routines to perform on-vehicle checkout and fault isolation to one or more LRUs, supplementing the limited built-in test. The STE is packaged in seven portable cases, five containing adaptors and cables and two the test equipment, and is transported by truck. To correct several shortcomings in the STE, a successor program, the Simplified Test Equipment-Expandable (STE-X), is currently in development, with a full-scale development decision expected early next year.[6] Clearly, the STE-X and the CTS have the same function and purpose, but the two programs apparently are proceeding in isolation of each other. Similarly, at the intermediate-forward maintenance level, the M1 and FVS are supported by

the Direct Support Electrical System Test Set (DSESTS), which is installed in a truck-mounted shelter and provides LRU testing and repair of 12 LRUs from the M1 and 13 LRUs from the M2/M3. The DSESTS is fully militarized equipment (MIL-T-28800C Type I, Class 3, Style A). As of September 1984, the Tank Automotive Command had procured approximately 600 STEs and 300 DSESTSs. Compatibility between DSESTSs and the BSTF apparently has not been specified in any plan.

The Army's policy on standardizing intermediate-level ATE, promulgated by message dated 6 June 1984 and effective as of 1 July 1984, is as follows:

- IFTE-BSTF/CTS will be the standard automatic testers for intermediate electronic maintenance applications for all systems scheduled for initial fielding after first quarter FY89.
- Systems entering production or full-scale development after second quarter FY86 must use IFTE components where ATE is required.
- Programs that currently rely on the use of other ATE systems and will remain in use after FY92 must conduct economic analysis to determine the advisability of converting their TPSs to IFTE. No product improvements to prolong the life of nonstandard ATE will be authorized after FY87 without an economic analysis and the approval of PM, TMDE.
- Development of unit level ATE will not be initiated without appropriate approval by PM, TMDE. The STE-X/CTS will first be considered as the objective ATE solution to test requirements, to include development of expansion modules. Specific plans to use a system other than STE-X/CTS must be identified to PM, TMDE. Systems fielded after first quarter FY88 or entering development after third quarter FY84 must consider the STE-X/CTS as their prime candidate for unit level ATE.
- Waivers of the standard ATE policy must be requested in accordance with Army Regulation 740-43 to obtain concurrence of PM, TMDE.
- All configurations of the AN/USM-410 or OQ-290 used forward of the echelon above corps level will be programmed for replacement by IFTE.

In summary, the Army only recently decided on a clear direction for its ATE programs. Apparently, that direction was needed in light of recent problems, such as the fielding at

[6]The practical problems associated with the use of STE in the field are described in Frans Nauta, Fix-Forward: A Comparison of the Army's Requirements and Capabilities for Forward Support Maintenance, Task ML104 (Bethesda, Maryland: Logistics Management Institute, April 1983) (AD A133954).

intermediate (rear) maintenance of a standard ATE that was already obsolete,[7] and the lack of standard ATE at intermediate (forward) maintenance until at least the early 1990's. If the IFTE program is successful, it will solve a large part of the Army's present ATE problems.

Marine Corps

Because ATE requirements are driven by the supported weapons systems, it is convenient to distinguish between Marine Corps aviation and ground equipment. The latter have had little or no need for field-level ATE in the past, but the technology of new weapons systems being introduced is beginning to impose such a need. The only item of standard ATE in the inventory is the AN/USM-465 digital card tester (or its functional equivalent, HMC-193, the Hughes Aircraft Corporation's version of the GENRAD-2225), which is also used by the Army and surface Navy. Compared to the hundreds of TPSs fielded in the Army, the Marine Corps ground has less than 10, but over 100 are under development.

In contrast, Marine Corps aviation has more experience with ATE. Materiel acquisition for aviation (aircraft, support equipment, provisioning) is a Navy responsibility. As a result, Marine Corps aircraft that are also in the Navy inventory are supported the same way. For example, the Marine Corps supports the F/A-18 with the same type of maintenance organization as in the Navy, with the identical large-scale ATE at the intermediate level. For the F/A-18, this includes three members of the Navy's standard ATE family and one peculiar test system for the F/A-18 radar system (AN/APG-65) WRAs:

- IMUTS II (AN/USM-608): A special-purpose hybrid tester for inertial navigation system WRAs, which currently supports both the AN/ASN-92 (not on the F-18) and the AN/ASN-130 aboard the F/A-18. This tester is of rack-and-stack design, two racks wide.

[7]For example, in a letter report to AMC, the U.S. General Accounting Office (GAO) quotes a December 1983 message from the Army's European Logistics Assistance Office to AMC Headquarters; the message concludes that "further fielding of the EQUATE (AN/MSM-105) within the U.S. Army Europe will offer no improved readiness or any increased ability to go to war." The European office requested that fielding be halted in favor of leasing state-of-the-art ATE. See: U.S. General Accounting Office, "GAO Concerns Relating To Additional EQUATE Procurements and Improvements," GAO Flash Report No. NSIAD-84-152 (Washington, D.C.: U.S. General Accounting Office, 17 August 1984).

- Automatic Test System [AN/USM-470(V)1]: A general-purpose hybrid tester for avionics WRAs. Also referred to as the Mini-VAST (Versatile Avionics Shop Tester), this ATE combines some second-generation stimulus building blocks from the VAST with commercial third-generation measurement instruments. The computer and peripherals are commercial off-the-shelf equipment. The system comprises six racks.

- Hybrid Test System (AN/USM-484): A general-purpose hybrid tester for avionics shop replaceable assemblies. It has some commonality with the Navy's other standard testers, and uses primarily commercial equipment, with the same computer and peripherals as used in the automatic test system. It is installed in four racks.

- RTS (Radar Test Station): Special-purpose tester for radar WRAs, installed in 5½ racks of equipment. Most of the equipment (about 75 percent) is commercial off-the-shelf, the rest is specially designed for this ATE.

Although the AV-8B Harrier II program is managed by the Navy, it is being acquired to meet a peculiar Marine Corps requirement. The ATE for intermediate-level maintenance of the AV-8B was developed to meet the needs for forward deployment. As a result, it consists of four small testers (each composed of three fully militarized boxes, two common among the four testers and one peculiar to the testing application: controls, displays, navigation, and armament) that provide the full capability of WRA testing at forward sites. Known as the "expeditionary test set," it meets the operational requirements of minimum size and weight, mobility, and resistance against rough environmental conditions.[8] It represents the first field-level ATE in the DoD inventory that was developed with particular emphasis on the operational environment in wartime. Prototype demonstrations were held in 1982, and first delivery of the production version will begin in late 1985.

To deal with the increasing need for ATE in nonaviation weapons system support, the Deputy Chief of Staff (Installations and Logistics) chartered a working group in 1980 to formulate Marine Corps policy for the development, acquisition, utilization, and management of ATE. The outcome of that effort was the establishment of the Automatic Test Services Unit (ATSU) within the depot maintenance activity at Marine Corps Logistics Base, Albany, Georgia, and the issuance of Marine Corps Order 10510.18, "Policy and Responsibilities for Test, Measurement, and Diagnostic

[8]A technical description may be found in: D. L. Williams and W. J. Austin, "The Expeditionary Test Set — A Fresh Approach To Automatic Testing," Proceedings AUTOTESTCON '83 (New York: The Institute of Electrical and Electronics Engineers, 1983), pp. 186-191.

Equipment (TMDE)" (current version A, dated 2 February 1982). That policy emphasizes the preference for general-purpose TMDE, but points out that TMDE selection should not be based on standardization alone; other factors include cost effectiveness, environmental requirements, state-of-the-art, and future measurement requirements. As a general rule, non-Fleet Marine Force units (i.e., the supporting establishment in the continental United States) will use commercial equipment, while Fleet Marine Force units may use modified commercial or militarized equipment if commercial equipment is inadequate. The Marine Corps Order also established a standard ATE program which requires that hardware and software of planned ATE be compatible with the specific parameters and characteristics of the standard ATE. To stem proliferation of ATE, all procurements or modifications of ATE need to be approved by the Commandant of the Marine Corps (Material Acquisition Support Branch). The ATSU was established to provide the technical and engineering services in support of the standard ATE program, including:

- Development of TPSs
- Certification and approval of all TPSs prior to fielding
- Configuration control of all TPSs and ATE
- Technical assistance to Headquarters Marine Corps and ATE users
- Advice on ATE selection to meet specific support requirements.

Since its inception, ATSU has taken the lead in developing the concept for a Marine Corps Automatic Test Equipment System (MCATES) and is currently actively engaged in implementing it. The ROC for MCATES was approved in October 1984. MCATES comprises two separate products: (1) a TPS Development and Management System for installation at ATSU, and (2) common ATE stations for fielding at both depot- and intermediate-level maintenance organizations in the Fleet Marine Force.

The TPS Development and Management System is designed to support development, verification, production, distribution, and configuration management of test programs. It consists of a Digital Equipment Corporation VAX-11/780 computer with a series of micro-VAX work stations

connected through a network. Test programs will be developed in the DoD-approved Institute of Electrical and Electronics Engineers, Inc. (IEEE) Standard 716, "Common/Abbreviated Test Language for All Systems (C/ATLAS) Language." The Marine Corps will use the Navy-developed Hierarchical Integrated Test Simulator as its standard digital automatic test program generator.

The MCATES test stations are fully commercial. They use a standard bus architecture (IEEE Standard 488-1978, "Standard Digital Interface for Programmable Instrumentation") and will be installed in standard Marine Corps shelters and vans. ATSU has selected the 68000 microcomputer with UNIX operating system software as the standard instrument controller; standard peripherals include cathode ray tube, disk drive, and dot matrix printer. ATSU is currently in the process of selecting commercial, general-purpose ETE compatible with the IEEE 488-1978 bus. For the test head, ATSU has established the following characteristics: direct memory access with data transfer at 500K bytes/second; drivers/sensors with a dual threshold over a range of −28 to +28 volts; 10 MHz test rate; and an interface with 748 pins with flexible switching, allowing any individual pin to provide stimulus or measurement. The test station is similar to the commercial ATE found in industry.

Among the essential characteristics specified by the ROC are the following: capability of being used 23.5 hours/day with 30 minutes for scheduled maintenance; self-test capability to fault isolate to a single card or module 90 percent of the time and no more than three modules the remaining 10 percent of the time; and resistance to shock and vibrations within the shelter or van in which the test station is installed. Importantly, the ROC anticipates obsolescence on a 5-year cycle with the need to upgrade the instrument controller and test head elements under a preplanned product improvement program.

The first MCATES test station is planned for completion in 1985 with full operational capability in FY88. The inventory objective is 190 stations, with 173 programmed to be procured through FY90, at a total procurement cost of $20.6 million (zero development cost). The 15-year life cycle cost for these units and ATSU's operation of the TPS Development and Management System for test program updates (not initial development) is estimated at $57.4 million (FY85 dollars).

Observations

The ATE programs of the Military Services are designed to meet specific requirements. As a consequence, efforts to achieve interservice standardization will not be fruitful, primarily because most of the programs are too far along to be susceptible to major change. Moreover, the differences in operational environment and mission requirements of the ATE are real. The Air Force's program is designed to control costs, the Navy's to maximize throughput capacity within a constrained space, the Army's to meet mobility and diverse workload requirements at the intermediate (forward) level, and the Marine Corps' (for ground equipment support) to minimize cost. Because of "vertical commonality" requirements (to ensure compatibility of test results), efforts to standardize at the depot level (where operational environment and mission requirements are identical) would probably yield few benefits.

INVENTORY MANAGEMENT

Inventory management of ETE includes such actions as: monitoring the inventory of common ETE, distributing common ETE to where it is needed, replacing items that are lost or disposed of, provisioning spare parts for items that are org nically repaired, monitoring technical obsolescence and/or support obsolescence (unavailability of parts) to initiate modernization replacement, and monitoring the use of common ETE to identify shortcomings in fielded items and initiate corrective actions. Many of these functions, however, are not being performed or they are being only partially performed because: the function was not included in the organization's formal responsibilities; the resources (personnel, money, and time) are not available; and/or the information needed to carry out the function is not available. In the balance of this section, we examine several aspects of inventory management of ETE in more detail.

Management Systems

To manage a large inventory of equipment, an automated data base and, preferably, a management information system (MIS) that interfaces with the data base are required. None of the Military Services has a complete and accurate data base for common ETE. The implications are that

overages/shortages in test equipment cannot be identified, pending obsolescence cannot be anticipated, and contingency plans for meeting shortfalls cannot be maintained.

The Army is developing an automated data base. A test equipment MIS development effort is currently underway at CTA, with a first version scheduled to be available in September 1985. However, the data base will not be fully loaded for several years.

The Navy developed its first automated data base for GPETE in August 1984 by taking an extract off the MEASURE (Metrology Automated System for Uniform Recall and Reporting) data base. NAVELEX believes that data base contains 85 percent of its GPETE inventory. It does not plan to develop a separate MIS for GPETE.

The Air Force has several computer systems that together constitute the Air Force Equipment Management System. The Support Equipment Acquisition and Control System (Code C013) contains data on all support equipment, including ETE and ATE, in the Air Force's inventory. That system, developed at Ogden ALC, Utah, in 1975 and operational since 1979, was transferred to AFLC Headquarters in 1982 and is designed to provide a central means for collecting/disseminating data on support equipment availability through 16 monthly and quarterly reports to ALC item and system program managers, major commands, and Air Staff. Specific procedures and reporting formats are described in Air Force Manual 67-1, U.S. Air Force Support Manual, Vol. IV, Part 1, Chapter 28, March 1982 and Vol. III, Part 7, August 1979. A recent audit, however, reported that this data base contains many errors and is incomplete, that past attempts to correct the deficiencies have not been successful, and that the reports generated by this system are not used.[9] The long-term solution, according to AFLC, is to upgrade the system as an integral part of the Air Force Equipment Management System redesign program. Implementation of the latter effort is planned for FY87.

[9]Air Force Audit Agency, "Review of the Support Equipment Acquisition and Control System" (Norton Air Force Base, California: Headquarters Air Force Audit Agency, 10 July 1984)

The shortcomings in that system have forced San Antonio ALC, the Air Force's item manager for FSC 6625, to work from a manual ledger system to manage and control an inventory estimated at 800,000 items. With respect to ATE, however, the San Antonio ALC has developed the only ATE MIS in existence.

Provisioning

Most of the ETE inventory, both general-purpose commercial equipment or special-purpose militarized equipment, is repaired in-house. To make those repairs, spare parts must be provisioned and stocked. Yet, much of DoD's test equipment tends to become unsupportable within a few years of fielding because the spare parts are not available. The cause of this rapid "support obsolescence" of test equipment (i.e., the inability to provide spare parts within a relatively short time of procuring the end item) is twofold. One is the lack of long-term planning of spare parts requirements, and the other is the reluctance to accept substitute parts in an attempt to maintain strict configuration control, which makes item management easier.

Commercial test equipment vendors follow a variety of procedures in providing product support after production of the end items is discontinued. The following describes the procedures of one of the larger manufacturers, Tektronix, which has a corporate program for support that is probably more extensive than that provided by many other vendors.[10] For the first 6 years after the product is dropped from the catalog, the company provides "full support"; i.e., replacement parts are guaranteed to be available. In the 7th through 9th year after phaseout, the company provides "limited support," which means maintenance service is no longer company-wide, but limited to designated service centers; replacement parts are stocked according to demand and vendor availability, while prices will escalate because of custom manufacturing; and accessories and calibration fixtures may no longer be available. After the 9th year, the product is considered "obsolete"; i.e., technical support is only available on a "best effort" basis, product-specific parts are no longer available, technical information is

[10]The source of the information is a paper presented by Walter Karsted, "Long-Term Product Support at Tektronix," Proceedings of the Electronic Test Equipment Division's Annual Program Review (Arlington, Virginia: American Defense Preparedness Association, May 1984).

still available for another 6 years, and manufacturing rights may be made available to other parties on a case-by-case basis. Exceptions to this corporate product support program include some original equipment manufacturer products, probes, and accessories; suppliers going out of business; and "special products." Tektronix informs its customers about the support situation for its products and defines the last year of support in advance to prepare the customer for replacement or parts buy-out decisions. While the postproduction support offered by Tektronix may be better than that of some other test equipment manufacturers, advance customer notification of product phaseout and support termination are standard industry practices.

Because of competitive pressures in the commercial ETE marketplace and rapid technology advances, the time a particular product is in production is relatively short, and it is becoming shorter. It may take only 2 or 3 years for a product to be phased out and replaced by another model offering competitive advantages (more capability or lower price). Furthermore, with the exception of some special products (e.g., high technology areas such as microwave test equipment), DoD is but a small customer overall. The notion that DoD can influence significantly the commercial ETE industry is unrealistic.

The spare parts problem for special, militarized test equipment is even more serious than it is for common, commercial test equipment. After the last end item has been produced and delivered under a procurement contract, manufacturers generally do not keep a production line open to provide spare parts to the DoD. While initial provisioning parts are normally included in the end item procurement contract, the quantities of those parts are more often based on available budget than on an engineering assessment. Buying replenishment parts later usually is very expensive and, in most cases, not worth the effort to the manufacturer because they would have to be produced at the expense of current production, which is needed to meet current market demands.

The solution to the parts supply problem of both classes of test equipment is straightforward. Item managers need to project the long-term parts requirements for each end item when they buy it, update those projections based on experience data from the field, and procure the required parts in multiyear contracts. They also need to act upon product support notices received from

industry. If cost effective, they should continue supporting fielded equipment with substitute parts (interchangeable by form, fit, and function, or parts that are upwards compatible) under appropriate configuration management (not control) procedures; otherwise, they should phase out the fielded equipment for which no parts are available. Additionally, the Military Services need to elevate the funding priority for test equipment spare parts above that for new test equipment.

Modernization

The Marine Corps estimates that more than one-half of its principal items of common test equipment (350 line items, excluding small value items and ancillary items) is 8 years or older; 25 percent is 12 years or older. It has no specific procedure for identifying obsolete items, nor does it have any modernization plans or programs.

NAVELEX estimates that 13 percent of its GPETE line items (which amount to about 30,000 line items with a 550,000 item count) is obsolete because spare parts are not available. NAVELEX has been submitting budget requests for replacement of obsolete items, but these requests have not been funded by the Navy. It does not have a separate line item for modernization of fielded, obsolete equipment; those requirements are commingled with procurement of new common ETE in a single budget line. Since GPETE is a "stock funded" item in the Navy, Naval Supply Systems Command is responsible for replacing equipment that is damaged beyond repair or otherwise disposed of and also for funding depot-level repairs to maintain a ready-for-issue inventory in the supply system.[11] (As far as the Fleet is concerned, the stock funding of GPETE means that a unit can obtain a replacement for a damaged item only by submitting to SPCC a funded requisition citing the Type Commander's operating budget or, in the case of aviation units, to the Aviation Supply Office.) It appears that such a fine distinction between an item that is unrepairable because of damage (with a repair limit set at 75 percent of the unit price[12]) and an item that is unrepairable because repair parts

[11]NAVELEX Instruction 5450.229, "Policies, Procedures, and Responsibilities for Navy General Purpose Electronic Test Equipment (GPETE)," (Washington, D.C.: Department of the Navy, 24 June 1974).

[12]Mary B. Acton (Deputy for Management and Analysis), Repair Strategy Assessment, Part I – Depot Maintenance (Alexandria, Virginia: Headquarters Army Materiel Command, January 1985).

are not available would create problems for the Navy in budgeting for modernization of obsolete test equipment.

San Antonio ALC attempts to review all of its FSC 6625 line items every 5 to 7 years. Those reviews identify items that are or soon will become unsupportable and result in budget requirements for replacements. In view of the magnitude of the inventory (54,000 NSNs), this approach has serious practical limitations.

The Army is the only Military Service that has a formal, separately funded and fenced, common TMDE modernization program (TEMOD).

The total Army inventory of TMDE is estimated to consist of 58,000 separate makes and models (NSNs), with 18,000 NSNs in FSC 6625.[13] The high-density line items are only 4,400 (all FSCs), including 2,500 in FSC 6625. The TEMOD program is focused on the high-density makes and models of TMDE. It was initially limited to FSC 6625, but the master plan, completed in September 1983, extended the program to all FSCs in three phases (see Table 2-1). While the second phase started in FY85, the first phase is still in progress. Priorities are determined in coordination with the U.S. Army Training and Doctrine Command (TRADOC), which represents the users, and the first such meeting took place in May 1984. The actual management of modernization in classes other than FSC 6625 is delegated by the PM, TEMOD to the major subordinate command that is the item manager for the equipment concerned (such as the Missile Command for FSC 4935).

The 1981 funding profile was $37 million per year over a 5-year period. The program, however, has not been fully funded. After transfer to the PM, TEMOD, the funding was increased to an average $30 million annual level for FY84 through FY86, with an additional $10 million in the outyears. Instead of representing a "one-shot" program, as originally conceived, the Army has decided to replicate the program in the future on a 7- to 10-year cycle.

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[13]General Richard H. Thompson, Luncheon Meeting Speech, National Security Industrial Association 1984 National Conference on "Supporting Weapon System Technology Through the 1990's" (Denver, Colorado: 16 August 1984).

TABLE 2-1. ARMY TMDE MODERNIZATION PROGRAM

PHASE	START	TMDE	NUMBER OF FSCs	IDENTIFICATION OF FSCs	NUMBER OF LINE ITEMS	PERCENTAGE OF PROGRAM
I	FY81	Common ETE	1	6625	2,543	57.6
II	FY85	Fire control, missile, aviation	6	4920, 4931, 4935, 5985, 6130, 6630	935	21.2
III	FY89	Other	59	—	431	9.8
Excluded		Other DoD	23	—	505	11.4
TOTAL			89		4,414	100 0

The current program is planned to reduce the 2,543 high-density line items of common ETE to 60 makes and models. With completion of the Phase III modernizations, the 3,909 high-density line items of all TMDE will have been reduced to approximately 600 makes and models.

In summary, the Military Services have not provided the resources nor have they established the policies and procedures needed for effective management of the test equipment inventory. Although current efforts to improve management information will bring some relief, they are not sufficient. In addition, both the Navy and Air Force need to adopt a formal ETE modernization program, much like the Army's.

PEACETIME VERSUS WARTIME REQUIREMENTS

Test equipment acquisition and inventory management in each of the Military Services is subject to budgetary constraints that have resulted in shortages of required wartime test equipment. The precise extent of these shortages is unknown. None of the Military Services has a management system in place to (1) monitor wartime test equipment requirements versus on-hand inventory, (2) assess the impact of test equipment shortages on maintenance capabilities, and (3) plan emergency procurements of test equipment needed for mobilization or in support of wartime contingencies. The implications of these shortcomings are clear: current test equipment shortages inhibit meeting the readiness and sustainability objectives stated in the current Defense Guidance. While it may not be affordable or cost effective to have in the peacetime inventory all the test equipment required in

wartime, the Military Services have no visibility on the extent of the shortfall nor on the contingency plans needed to overcome it.

Army

Although most of the Army's nondivisional intermediate maintenance capability is provided by maintenance units in the Reserve Components (only 23 of 134 nondivisional maintenance companies are in the Active Component), most of those units do not have the tools and test equipment required to perform their wartime maintenance mission. For example, the 5th Army, which is planned for early mobilization and deployment to in wartime, includes 30 maintenance units, 26 of which are in the Reserve Component. None of the Reserve Component maintenance units has the tools and test equipment to carry out its maintenance mission. In 1984, the U.S. Army Forces Command (FORSCOM) estimated the shortfall in test equipment authorized by Modified Table of Organization and Equipment (MTOE) at approximately $425 million for all nondivisional maintenance companies in the Reserve Component. The Army, however, is not funding that shortfall.

Furthermore, many of the tools and test equipment required by those maintenance units are not listed in their MTOEs. A considerable portion may be hidden under a "sets, kits, and outfits" line item or may be identified only in the Repair Parts and Special Tools List or the Maintenance Allocation Chart for the prime equipment that the units will be supporting. The Army's extensive modernization, currently underway, also necessitated modernization of the special tools and test equipment possessed by Reserve Component maintenance units. The Deputy Chief of Staff for Logistics (DCSLOG) recently initiated a program to purchase special tools, test sets, and other mission-critical items not authorized in unit MTOEs. This program, currently known as Reserve Component Transition to Modernization, provides for incremental funding for early deploying units and for selected prime equipments. The current funding level is at $55 million (FY85 through FY90) which covers the special tools/test sets for 38 units to support eight new weapons systems. This program is now being expanded to 51 units and 15 new weapons systems. Importantly, the Army considers the current lack of such non-MTOE authorized tools and test equipment for nondivisional Reserve Component units to be potential "war stoppers."

Two additional observations on upgrading the tools and test equipment of Reserve Component maintenance units appear to be warranted. One is that the Army is not fielding the EQUATE with the Reserve Component. Yet, that equipment will be the main item of test equipment that light equipment maintenance companies (intermediate rear) need to perform their mission. Wartime operating hours for much of the Army's electronic equipment exhibits a steep increase over peacetime operating hours, resulting in an ATE workload that is a large multiple of that in peacetime. Under the planned ATE deployment, much of that workload would be in excess of ATE throughput capacity, necessitating evacuation of the excess workload to continental U.S. depots or contractors plus increased forward stockage of spares. Concern about this wartime gap in ATE capacity was first expressed in a 1979 study conducted by the Deputy Chief of Staff for Research, Development, and Acquisition and forwarded to the Commander, AMC.[14] The Army has not yet resolved this issue.

The second observation is that the MTOE authorization of standard test equipment may be short of wartime requirements. Among maintenance supervisors there is a consensus that the current authorization of one STE-M1 per maintenance company is insufficient in wartime and should at least be doubled. (Because the STE-M1 has some shortcomings itself, it may be cost effective to defer increasing the density of this equipment until the product-improved version, STE-X, is fielded.) However, the TRADOC does not have the analytical tools to assess wartime TMDE requirements in preparing Basis of Issue Plans.

In sum, the Army has a wartime test equipment shortfall of unknown billions of dollars. With the recent DCSLOG initiative, it has taken a first step toward resolving that shortfall.

<u>Navy</u>

The Navy's shortage of manual ETE in the active Fleet is illustrated best by the need for "cross-decking" support and test equipment between ships that have returned from a cruise and those preparing for deployment. On the one hand, this procedure may be viewed as maximizing the use of

[14]Lieutenant Colonel Douglas H. Barclay, "An Analysis of the Army's Automatic Test Equipment Program" (Washington, D.C.: Office of the Deputy Chief of Staff for Research, Development, and Acquisition, November 1979), forwarded by letter from Lieutenant General Keith to General Guthrie, 27 November 1979.

expensive support equipment and reducing inventory and ownership costs. On the other hand, it shows that the Navy's test equipment inventory is insufficient to support the peacetime operating tempo, when only one-third of the Fleet is deployed at any time. In wartime, when the Navy plans to at least double its operating tempo, cross-decking would no longer fill the test equipment allowances of all deploying ships.

The impact of ATE throughput constraints on wartime sustainability of naval air operations has been examined in a few studies. For example, a recent study concludes that ATE capacity aboard aircraft carriers is the main bottleneck in supporting the planned S-3A wartime flying hours.[15] Since carriers do not have space for additional ATE, the only alternative is to increase shipboard stocks of WRAs and SRAs and possibly take other actions such as those explored by the Defense Resource Management Study.[16] The Navy, however, has so far not resolved this issue and appears to rely on the next generation of ATE (CASS) to solve the problem; CASS, however, will not be operational until the early 1990's.

Air Force

The Air Force estimates that it has a $1.5 billion shortfall in support and test equipment, with almost 80 percent of that shortfall in test equipment.[17] It acknowledges that this shortfall would have an impact on its wartime operations, but it does not have any formal plans to eliminate the shortfall.

ATE constraints on Air Force wartime operations is a recurring theme in several studies. For example, a well-documented study by The RAND Corporation clearly demonstrates that F-15 operations cannot be sustained in wartime with the planned support resources.[18] The study

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[15]T. F. Lippiatt, et al., Carrier Based Air Logistics Study: Integrated Summary, R-2853-Navy (Santa Monica, California: The RAND Corporation, January 1982) (AD A113289).

[16]Donald B. Rice (Study Director), Defense Resource Management Study (Washington, D.C.: U. S. Government Printing Office, February 1979).

[17]Major General Monroe T. Smith (Study Chairman), Support Equipment Acquisition Review Group Final Report (Wright-Patterson Air Force Base, Ohio: Air Force Acquisition Logistics Center, July 1984).

[18]J. R. Gebman, et al., Support Improvements for F-15 Avionics, Vol.2, Analysis (U), R-2591/2-1-AF (Santa Monica, California: The RAND Corporation, March 1983).

estimates that several hundred million dollars must be invested in additional ATE and additional avionics LRUs in war readiness spares kits to sustain F-15 wartime flying hours.

Observations

Considerations of peacetime cost effectiveness have driven the Military Services to lower their test equipment inventories below the levels required to sustain wartime operations. Given competing budget demands, this approach may be sound from the management perspective as long as the test equipment shortfall is not forgotten and plans are developed to meet that shortfall in an emergency.

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3. TEST EQUIPMENT SUPPORT MANAGEMENT

This chapter describes how the Military Services are organized to repair and calibrate ETE.

OVERVIEW

The Military Services have different approaches to ETE support. Army policy calls for each unit to perform organizational-level, mainly preventive, maintenance on assigned ETE. More complex repairs, as well as all calibration of ETE, are to be performed by specifically designated calibration and repair units (for general-purpose TMDE) or intermediate maintenance units (for special-purpose TMDE). The Navy assigns more ETE repair responsibility to owning units than does the Army. However, if those units encounter repairs beyond their capability, they must find another organization that can perform the repairs. The calibration of ETE within the Navy is separate from the repair function; it is performed by a variety of calibration laboratories and activities. The Air Force's approach to ETE support is quite different from that of the Army and Navy in that it assigns a substantial ETE repair and calibration capability to operating units at the base level.

These differences in ETE support are understandable considering the different missions that they have been assigned and the different environments in which they must operate. The Army, for example, does not find it practical to equip combat units with the capability to perform significant repairs of ETE or to calibrate it. The Navy places similar restrictions upon its operating units primarily because of space limitations aboard ships. In contrast, the Air Force operates from large bases that can be readily provided with the capability to repair and calibrate much of its ETE.

The organizational structure and procedures for test equipment calibration and repair are complex. The following sections first provide general information on each Military Service's calibration system and test equipment support policies as introduction to a summary description of calibration and repair organizations and procedures. The chapter concludes by outlining some concerns about wartime planning for test equipment support and the support equipment (calibration standards) itself.

CALIBRATION SYSTEM ORGANIZATION

Calibration is defined in MIL-STD-1309C, "Definitions of Terms for Test, Measurement, and Diagnostic Equipment," as follows:

> The comparison of a measurement system or device of unverified accuracy to a measurement system or device of known and greater accuracy to detect or correct any variation from required performance specifications of the unverified measurement system or device.

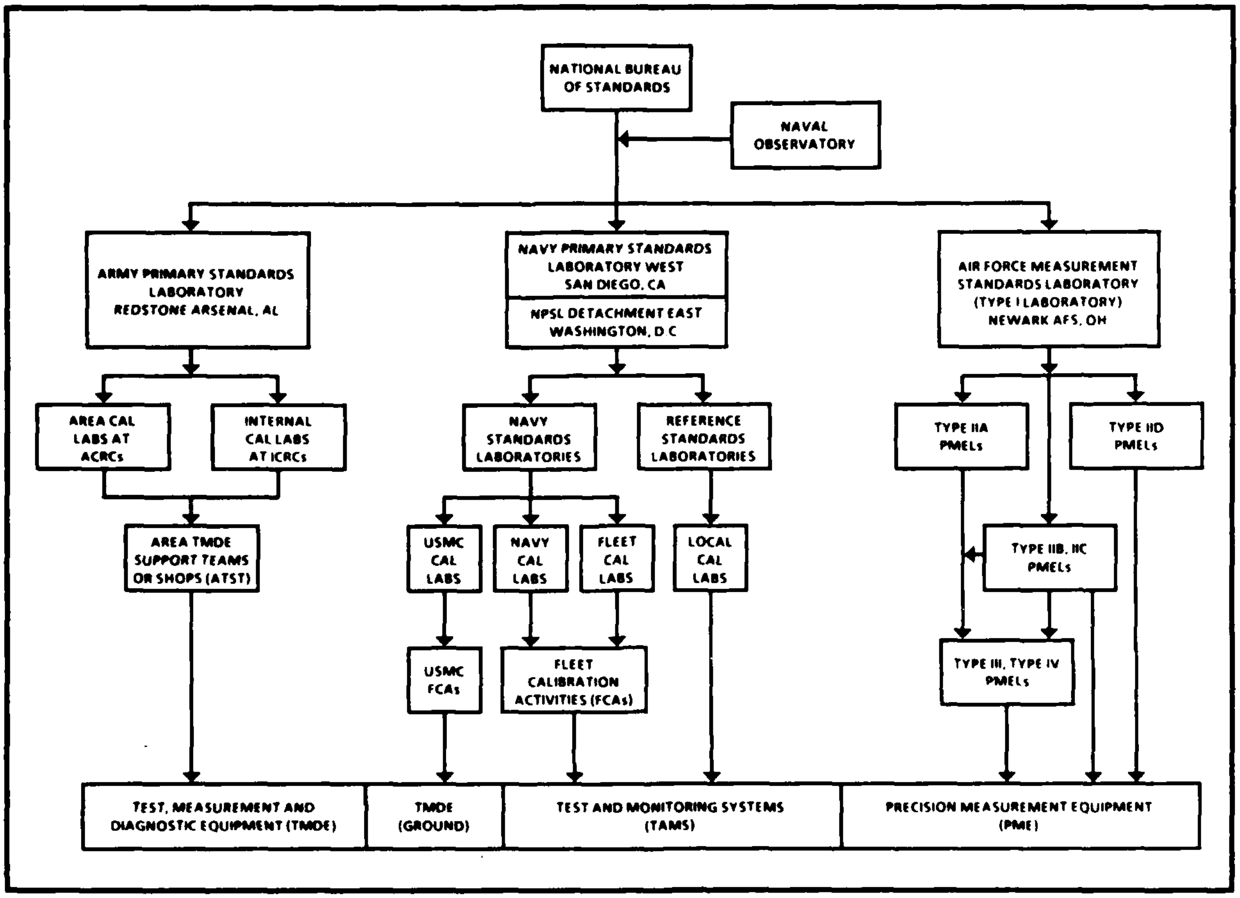
Each of the Military Services has a metrology and calibration (METCAL) program to ensure that test equipment used in weapons systems maintenance is accurate. Those programs consist of a hierarchy of reference and transfer standards that are traceable to the national standards, and are maintained, controlled, and available to the calibration activities responsible for test equipment calibration.

The national standards for mass, length, temperature, light, and current are maintained by the National Bureau of Standards (NBS), while those for precise time and time interval are maintained by the Naval Observatory. As shown in Figure 3-1, the high-level laboratories within the Military Services are similarly structured but there are many differences at the lower echelons. A brief description of each echelon follows.

Type I Laboratories

The primary standards laboratories maintain the highest measurement standards. They support the Type II laboratories by providing metrology engineering and calibration services for their reference standards. The Army and Air Force each have one primary standards laboratory, while the Navy has two. (Officially, the Navy Primary Standards Laboratory East, located in Washington, D.C., is a detachment of the Navy Primary Standards Laboratory West that is located at the Naval Air Rework Facility (NARF), North Island, San Diego, California). The Army's laboratory is managed and operated by the U.S. Army TMDE Support Group (USATSG); the two Navy laboratories by the Naval Air Systems Command (NAVAIR) through the Naval Aviation Logistics Center and NARF North Island; and the Air Force laboratory by the Aerospace Guidance and Metrology Center (AGMC), which reports to the AFLC. The Air Force Measurement Standards

FIGURE 3-1. DoD METROLOGY AND CALIBRATION SYSTEM



Laboratory at Newark Air Force Station, Ohio, maintains approximately 215 Air Force standards that are directly traceable to the national standards. The exact number of Army and Navy standards is unavailable.

Type II Laboratories

The level directly below the primary standards laboratories includes a wide variety of reference standards laboratories. Most of those laboratories provide calibration services for the working or transfer standards at lower level laboratories in a geographical area or at special repair activities; some provide calibration services for test equipment beyond the capability of lower-level calibration activities. (Although we distinguish here between calibration equipment installed at calibration activities and test equipment used by maintenance personnel, both are categories of test

equipment.) In spite of their differences, all Type II laboratories obtain calibration services for their standards from the Type I laboratory.

Army. The Army's secondary reference standards are maintained by Area Calibration Laboratories (ACLs), which are an organizational element of Area Calibration and Repair Centers (ACRCs); and Internal Calibration Laboratories (ICLs), which are attached to Internal Calibration and Repair Centers (ICRCs). ACRCs (and the associated ACLs) are established by AMC as subordinate elements of USATSG to provide single-source calibration and repair support for TMDE in a geographical area. The Army has five ACRCs [one in the continental United States (CONUS), three in Europe, and one in Korea]. Each ACRC is a military unit organized by a Table of Organization and Equipment, with a civilian augmentation per Table of Distribution and Allowances (TDA). ICRCs (and associated ICLs) are civilian TDA organizations, established by AMC, but are located at six Army depots in CONUS. Both ACLs and ICLs are operated as fixed facilities, although the ACLs are deployable but can only operate in environmentally controlled, semifixed facilities.

Navy. The Navy's Type II laboratories include Navy Standards Laboratories located at three NARFs (Norfolk, Virginia; Pensacola, Florida; and Alameda, California) and Reference Standards Laboratories located at all Naval Shipyards and Ship Repair Facilities, some Naval Weapons Stations, and the Navy Gage and Standards Laboratory, Pomona, California. They are all shore-based facilities, established under approval authority of NAVELEX [Test and Monitoring Systems (TAMS) Program Office, ELEX-08T], and operated as civilian TDA organizations. They provide regional metrology engineering and calibration services for standards and test equipment beyond the capability of Type III calibration facilities. Management and control of the NARFs is exercised by the Naval Aviation Logistics Center.

Air Force. The Air Force has four different categories of Type II Precision Measurement Equipment Laboratories (PMELs) that maintain base reference standards for the calibration/certification of working standards utilized at the next lower level or for metrology engineering and calibration services beyond the capability or reach of the next lower-level laboratories. The PMELs are owned and operated by the major commands, but they are established subject to the approval of

AGMC. Only one Type II PMEL is authorized at any base or installation. The four categories of PMELs are:

- <u>Type IIA PMELs</u>. This category includes six laboratories supporting the ALCs (including AGMC) and two laboratories supporting overseas areas that are operated by theater support commands. For example, the Type IIA PMEL supporting U.S. Air Forces in Europe is located at Bitburg Air Base, Federal Republic of Germany. The Type IIA PMEL supporting the Pacific Air Forces is located at Clark Air Base, The Philippines.

- <u>Type IIB PMELs</u>. This category includes the base PMELs located at all major Air Force bases. The Air Force has 92 of these PMELs worldwide.

- <u>Type IIC and IID PMELs</u>. These two categories are special PMELs supporting research, development, test, and evaluation programs conducted by AFSC Type IIC PMELs or tailored to a specific mission (IID). The Air Force has 10 Type IIC PMELs and 1 Type IID PMEL.

In drawing parallels between the Military Services, the Air Force's Type IIA PMELs are comparable to the Army's ACLs/ICLs and the Navy's Standards Laboratories/Reference Standards Laboratories, while the Type IIB/C/D PMELs have more limited capabilities. (The Type IIB and IIC PMELs receive calibration support from Type IIA PMELs.)

<u>Type III and IV Laboratories</u>

The lowest levels in the METCAL system comprise a wide range of calibration laboratories and activities, with pronounced differences among the Military Services. They include laboratories maintaining "working standards" for calibration of test equipment as well as various "user calibration" activities. Most of these laboratories and activities are staffed primarily by military personnel. All are supported by Type II standards laboratories.

<u>Army</u>. The Army's secondary transfer standards are operated by Area TMDE Support Teams (ATSTs). Thirty-four ATSTs are civilian-staffed, fixed shops located at research, development, test, and evaluation activities in CONUS (and one in Panama) for dedicated TMDE support. The balance of the ATSTs (140) are mobile teams with truck-mounted shelters housing the calibration standards. These teams include 61 that are staffed by civilians and distributed among the 6 CONUS-based ICRCs and 79 military teams distributed among the 5 ACRCs (45 teams in Europe, 17 teams in Korea, and 17 teams in CONUS). Most of the CONUS teams are deployable. The

overseas ATSTs either operate from fixed sites or as mobile calibration units providing on-site calibration of the test equipment of supported maintenance units. The Army discontinued user calibration ("Level C" calibration) in 1979 with its reorganization and consolidation of general-purpose TMDE calibration and repair. Special-purpose TMDE, however, is not supported by the ATSTs but through designated maintenance channels.

Navy. The Navy's Type III calibration laboratories, both ashore and afloat, provide calibration and repair of lower-level standards and of test equipment beyond the capability of Type IV calibration activities. The shore-based calibration laboratories include: Local Calibration Laboratories (located in shops at Naval Shipyards and Ship Repair Facilities), Navy Calibration Laboratories, and Fleet Calibration Laboratories at shore intermediate maintenance activities (SIMAs) and Aircraft Intermediate Maintenance Departments. The afloat calibration laboratories include Fleet Electronic Calibration Laboratories aboard each tender and repair ship to provide calibration of Fleet ETE; Fleet Mechanical Calibration Laboratories aboard Fleet Ballistic Missile (FBM) submarine tenders to provide calibration services for mechanical TMDE from both the tender and FBM submarines; and Mechanical Instrument Repair and Calibration Shops aboard specific tenders (other than those supporting FBM submarines) and repair ships to provide calibration/repair services for mechanical, pressure, and temperature measuring instruments installed aboard ships. The Type III calibration laboratories also include two Marine Corps calibration facilities, located at the two Marine Corps depots. These two facilities are supported by a designated Type II Standards Laboratory through periodic exchange of calibrated standards. (Marine Corps aircraft are supported by designated Navy Calibration Laboratories.)

The Navy formally recognizes a Type IV level of calibration, known as Fleet Calibration Activities. These activities are an organic part of organizational- and intermediate-maintenance organizations ashore and afloat. They do not provide scheduled calibration support to activities other than their own organization. They are staffed by specially trained military personnel and used primarily to calibrate specific TMDE that requires calibration each time it is used or on a very frequent basis, such as daily or weekly. The Marine Corps has similar types of activities.

Air Force. The Air Force has formally designated Type III and Type IV PMELs. Its 12 Type III PMELs are tailored to specific missions and receive calibration support from a Type II PMEL; they are not authorized at an installation where a Type II PMEL exists. Type IV PMELs are designated to support selected weapons systems through transportable calibration equipment in both fixed and deployed locations. They are supported by a designated Type II PMEL. The Air Force has 14 Type IV PMELs, including 5 installed at locations overseas. Additionally, 30 of its Type II PMELs possess transportable field calibration units that may be deployed to provide on-site calibration support. The Air Force also has approximately 100,000 items of TMDE that are calibrated by the user.

Observations

Table 3-1 shows that the Military Services operate almost 500 nondedicated calibration laboratories. [Excluded from that table are hundreds of dedicated calibration activities, i.e., activities with a dedicated calibration mission such as those at research and development facilities and most Type IV-level activities. For example, the Navy itself has about 480 standards and calibration laboratories.(Type II and Type III), most of which do not show up in this table.] Several past attempts to consolidate those facilities have not been successful although the benefits from consolidation appear to be substantial.

CALIBRATION AND REPAIR POLICIES

The Military Services have issued detailed policies for the management and implementation of their METCAL programs. In some respects, these policies are very similar. For example, they have similar approaches to determining and monitoring calibration intervals of test equipment and they use similar types of recall systems to control the calibration of general-purpose test equipment. Their policies also emphasize, to various degrees, the use of interservice support agreements (ISSAs) to reduce costs as long as military effectiveness is not impaired. In other respects, the policies are dissimilar, particularly in the areas of management and control of the calibration and repair of test equipment and in the maintenance concepts for test equipment. A brief description of these issues (management and control, maintenance concepts, and calibration intervals) follows.

TABLE 3-1. SUMMARY OF NONDEDICATED CALIBRATION LABORATORIES

MILITARY SERVICE	PRIMARY	SECONDARY REFERENCE	TRANSFER AND CALIBRATION	TOTAL
Air Force	1	9	128 fixed, 30 TFCUs[1]	168
Navy	2	20	59 fixed, 26 mobile	107
Army	1	11	34 fixed, 61 semifixed, 79 mobile	186
Marine Corps	—	—	2 fixed, 3 mobile, 8 transportable	13
TOTAL	4	40	284 fixed/semifixed 146 mobile/transportable	474

[1]Transportable field calibration units.

NOTE: The allocation by level for Air Force and Navy is based upon responsibilities (e.g., the Air Force's Type IIA and IID laboratories are shown as secondary reference laboratories, while Type IIB, IIC, III, and IV are shown as transfer and calibration laboratories).

SOURCE: T.O. 00-20-14, "Air Force Metrology and Calibration Program," 15 May 1982.

Management and Control

Army. The Army's principal calibration policy is contained in Army Regulation 750-25, "Army Test, Measurement, and Diagnostic Equipment Calibration and Repair Support Program," 1 October 1983 and Army Regulation 750-43, "Test, Measurement, and Diagnostic Equipment," 1 April 1984. Both the technical direction and the management and control of calibration and repair support of all general-purpose and some special-purpose TMDE is concentrated in USATSG. (The decision for USATSG to support selected items of special-purpose TMDE is made by the materiel developer of the supported prime equipment and USATSG based on operational constraints and cost effectiveness.) USATSG has technical control of the TMDE support program Army-wide; it exercises command and control of all ACRCs and designated ICRCs; it manages and operates the Primary Standards Laboratory; and it is responsible for development of calibration procedures and the acquisition of calibration equipment. It also publishes Technical Bulletin 43-180, "Calibration Requirements for the Maintenance of Army Materiel" (current issue dated 15 April 1983), which identifies

the calibration and repair requirements for TMDE used in the field. (The current issue lists about 4,200 line items with calibration required, and 2,300 line items with no calibration required.) USATSG is directed by the Commanding General, AMC, through the Executive Director for TMDE, who is responsible for managing the acquisition, logistics, and financial management of all Army TMDE. The major commands that use the calibration services provided by USATSG elements are responsible for maintaining a TMDE management program, providing facilities and support to calibration/repair activities, establishing calibration/repair support priorities for subordinate units, and coordinating their war plans with AMC to ensure that calibration and repair support is adequately addressed.

In summary, the Army has consolidated the calibration and repair support of most TMDE under a single organization that is responsible for technical direction as well as management and control.

Navy. The Navy's principal policy document on calibration and repair of test equipment is NAVELEX Instruction 4355.2, "Department of the Navy Metrology and Calibration (METCAL) Program" (draft April 1984). The Metrology Engineering Center, Pomona, California, under the administrative command of the Naval Weapons Station, Seal Beach, California, a NAVSEA field activity, is responsible for technical direction of the Navy's METCAL program. It develops and evaluates calibration standards and equipment, maintains the associated ILS plans, and promulgates the "Navy Calibration Equipment List " (NAVAIR 17-35 NCE-1, NAVELEX 0969-LP-170-5010, and NAVSEA OD48939). It develops or approves calibration procedures and documentation for all Navy calibration activities, and maintains the list of authorized procedures, "Metrology Requirements List" (NAVAIR 17-35 MTL-1, NAVELEX 0967-133-2010, and NAVSEA OD45845). It also determines and adjusts calibration intervals for test equipment and standards to meet required reliability levels. Overall management and control of the METCAL program is exercised by NAVELEX (TAMS Program Office, ELEX-08T). It has approval authority over the establishment, disestablishment, or expansion of any Type I, II, or III calibration laboratory. (Type IV Fleet Calibration Activities are established and approved by the Systems Commands.) The Systems Commands are responsible for

calibration and calibration support of all test equipment under their cognizance. NAVAIR's responsibilities include all aviation-associated test equipment; NAVSEA is responsible for all shipboard hull/mechanical/electric and combat system test equipment; and NAVELEX is responsible for shipboard and shore electronic test equipment. They operate assigned laboratories and provide funding for research and development, procurement, and logistic support (including calibration and repair) of metrology standards and for calibration and incidental repair of Fleet test equipment beyond the capability or capacity of the Fleet.

In contrast to the Army, the Navy has separated responsibility for the calibration and repair (other than incidental) of test equipment. Similarly, the technical direction, management, and operation of calibration laboratories are separate and performed by numerous organizations.

Air Force. The Air Force's principal policy documents are Air Force Regulation 74-2, "Air Force Metrology and Calibration (METCAL) Program," 8 February 1983 and T.O. 00-20-14, "Air Force Metrology and Calibration Program," 15 May 1982. Technical direction as well as management of the Air Force's METCAL program is concentrated in AGMC, subject to the overall oversight and policies established by AFLC (Deputy Chief of Staff for Maintenance). AGMC operates the Air Force's Type I laboratory. It determines which bases and installations are authorized a PMEL; it establishes and adjusts calibration intervals; it prepares and publishes technical orders for calibrating reference standards, precision measurement equipment (PME), and ATE; it maintains a system for evaluating PMELs; and it reviews prime equipment measurement requirements during development. It also determines requirements and initiates procurement action for new standards and calibration equipment. In contrast, AFSC is responsible for identifying test and measurement requirements, obtaining Support Equipment Recommendation Data, and developing or providing any new peculiar PME. The ALC system manager is responsible for development or procurement of any common PME, if required, before new or modified systems are operational. AFSC is also responsible, in coordination with AFLC and AGMC, for the development of new equipment required to support new PME. The major commands are responsible for maintaining and operating PMELs to calibrate and repair all common and designated peculiar PME of host, tenant, and off-base supported Air Force

activities (including those of Air National Guard and Air Force Reserve). They are also responsible for assisting supported activities with calibration and repair of peculiar PME not specified as a PMEL responsibility.

The Air Force has concentrated the technical direction and management of calibration in one organization, with the major commands (operating forces) responsible for operating the calibration laboratories that also provide repair support for most test equipment.

Observations. The extent of control by the user (operating forces) over calibration services has been at issue for several years. Currently, the user has no control in the Army, some control in the Navy, and considerable control in the Air Force. Furthermore, the Military Services also differ substantially with respect to their treatment of test equipment repair, particularly between the Navy and both the Army and Air Force. The biggest complaint in the Fleet with regard to test equipment is the weak repair support and the lengthy delays resulting from test equipment that is turned in for calibration being returned by the laboratory for repair elsewhere before it is accepted for calibration.

Maintenance Concept

By policy, the Army uses the LSA to develop a cost-effective maintenance concept for test equipment, including commercial off-the-shelf ETE, in accordance with MIL-STD-1388. Army policy also requires the U.S. Army Communications Command, U.S. Army Intelligence and Security Command, and AMC to determine maintenance float requirements for TMDE and to coordinate with USATSG that such floats are procured, supplied, and distributed to ACRCs. Other major commands, however, are not so directed. As a result, U.S. Army, Europe, for example, has not established a maintenance float except for some radiac items.

In contrast, the Air Force requires the ALCs to perform depot-level maintenance to restore PME to a serviceable condition. There is little consideration given to other factors that might influence that decision, such as LSA, cost effectiveness, complexity, and the use of commercial versus militarized equipment. The Air Force, like the Army, does not have any maintenance float for this type of equipment.

The Navy does not have a specific policy on test equipment maintenance although NAVAIR has been trying to develop a policy on the acquisition and life cycle support of commercial test equipment particularly for ATE. In practice, the Navy appears to have pursued a concept of maximum organic maintenance of test equipment, which has created a conflict with the long-term supportability of commercial test equipment. As a result of this conflict, the Navy has undertaken two studies to explore how commercial test equipment should be supported. One advocates maximum commercial support,[1] the other advocates organic support.[2]

The Marine Corps has always insisted on maximum organic maintenance capability for test equipment although local commanders have, by policy, the discretion to use either the Marine orps supply system or local commercial parts support.

It appears that the cost effectiveness of organic support of commercial test equipment is being overestimated. The alternative of commercial support, using float items to protect test equipment availability, may in many cases be the most cost-effective solution, especially in those instances in which the item density is low and the item technology is high (i.e., the item is subject to rapid obsolescence). These differences in maintenance concepts clearly illustrate the need for a DoD policy on test equipment support.

Calibration

The calibration interval, i.e., the time period between successive calibrations of the same test instrument, is defined as:

> . . . that period of time, based on an 8 hour operating day, that equipment has not degraded from the limits required by the detailed specification. [MIL-T-28800C, p. 136]

[1]Dialectic Systems Corporation, Commercial Test Equipment Report Phase I (Draft) (Washington, D.C.: Naval Air Systems Command, 13 August 1982).

[2]Harris Corporation, CTE Repair Study Phase II Report (Washington, D.C.: Naval Air Systems Command, 14 February 1985).

The same document recommends the initial calibration interval for new test equipment if the performance specification does not specify one:

> When the detailed specification does not require a specific calibration interval, the calibration interval shall be *nine months*, based on an equipment operating time of 1500 hours. [MIL-T-28800C, p. 80]

The Military Services use a common approach to determining and adjusting calibration intervals of test equipment. Initially, for new equipment, the interval may be set in accordance with manufacturer recommendations or like equipment in the inventory. (The purchase descriptions for commercial off-the-shelf ETE normally do not include calibration interval requirements.) Each of the Military Service's METCAL program includes a comprehensive system for monitoring the number and percentage of test instruments that are found out-of-tolerance when they are turned in for calibration. Based on such field experience, calibration intervals are adjusted until they meet individual Military Service criteria. For example, the Air Force's criterion is an end-of-period within-tolerance rate (also called reliability) of 85 percent, which corresponds to an average rate of 95 percent over the period between calibrations. The Navy and Army require an average rate of 85 percent, which corresponds to an end-of-period within-tolerance rate of approximately 72 percent for Navy and 75 percent for Army.

Furthermore, these rules have traditionally been applied to each make/model of test equipment, with little effort to discriminate among the different makes/models of test equipment and give each make/model its own reliability target as a function of criticality (e.g., safety-of-flight measurements) and out-of-tolerance rate. There are indications now that the METCAL community is beginning to recognize that this approach may not be appropriate.[3]

The issue of differential reliability targets seems more important than the issue of calibration interval differences, which has been the object of many studies over the past several years.

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[3]Steven R. Dwyer, "Reliability Targets for a Calibration Program," 1984 Proceedings Annual Reliability and Maintainability Symposium (New York: The Institute for Electrical and Electronic Engineers, Inc., 1984).

Ideally, the methodology for determining differential reliability targets to minimize calibration costs and maximize reliability should be standard throughout the DoD; however, the resulting calibration intervals for like equipment may, of course, be different among the Military Services.

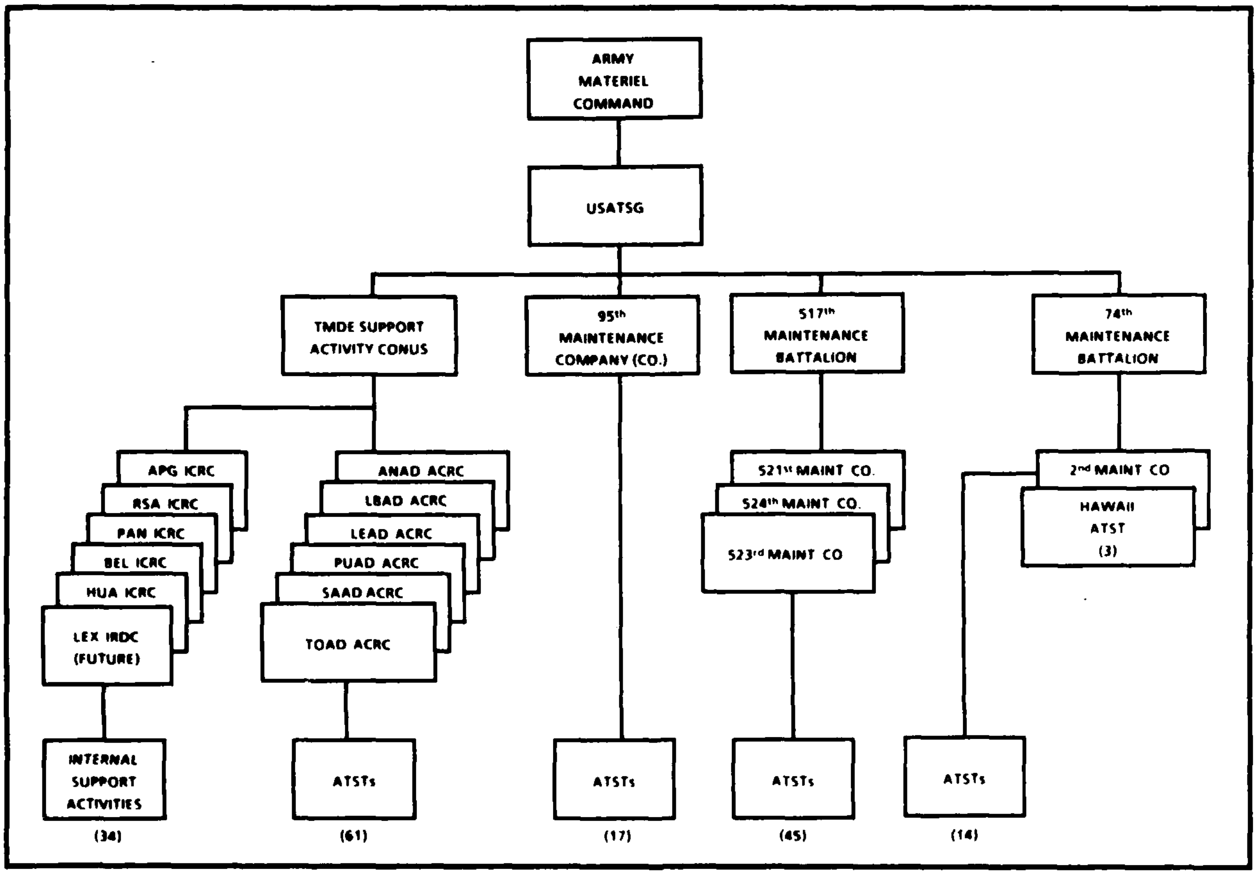
ETE CALIBRATION AND REPAIR

This section describes the test equipment calibration and repair organizations and capabilities within the Military Services.

Army

The Army's organizational structure for TMDE calibration and repair support is illustrated in Figure 3-2. Support in CONUS is divided between two organizations subordinate to USATSG: the U.S. Army TMDE Support Activity CONUS (USATSAC), which is a civilian TDA organization that provides support to TRADOC, the AMC industrial base, reserve components, and

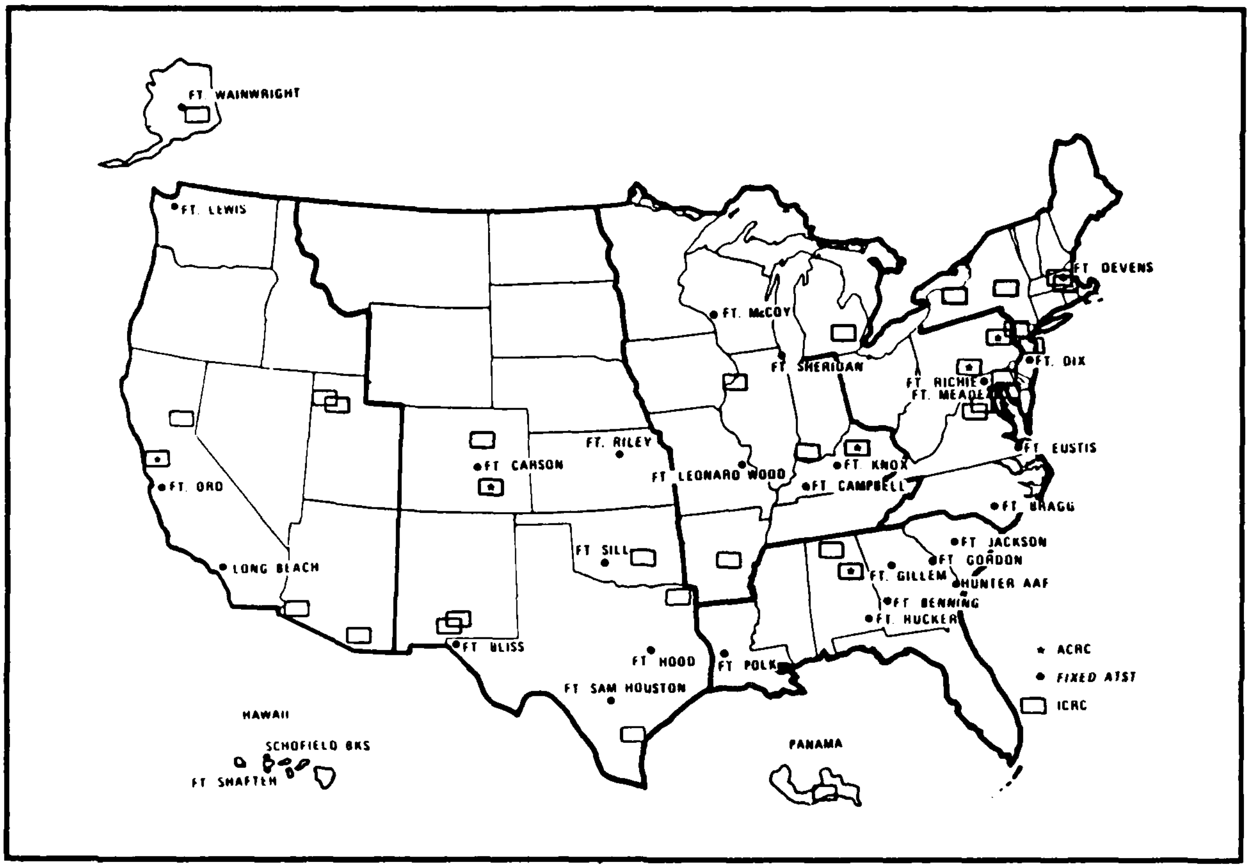
FIGURE 3-2. ARMY TMDE SUPPORT



nondivisional elements of FORSCOM; and the 95th Maintenance Company (TMDE), which is a military-staffed organization with headquarters at Redstone Arsenal, Alabama, providing support to the 10 FORSCOM divisions located at 9 CONUS installations.

The USATSAC comprises five (six in the near future) ICRCs that are tailored to the specific support requirements of the installations at which they are located and six ACRCs that are located at Army depots (Anniston, Alabama; Lexington-Bluegrass, Kentucky; Letterkenny at Chambersburg, Pennsylvania; Pueblo, Colorado; Sacramento, California; and Tobyhanna, Pennsylvania). Each of the ICRCs has an ICL, and, altogether, they operate 34 separate internal TMDE support activities. Each of the ACRCs has an ACL and is responsible for customer support in a specific geographic region (Figure 3-3). That support is provided by 61 ATSTs, which operate either

FIGURE 3-3. U.S. ARMY CALIBRATION ACTIVITIES NONDEPLOYABLE

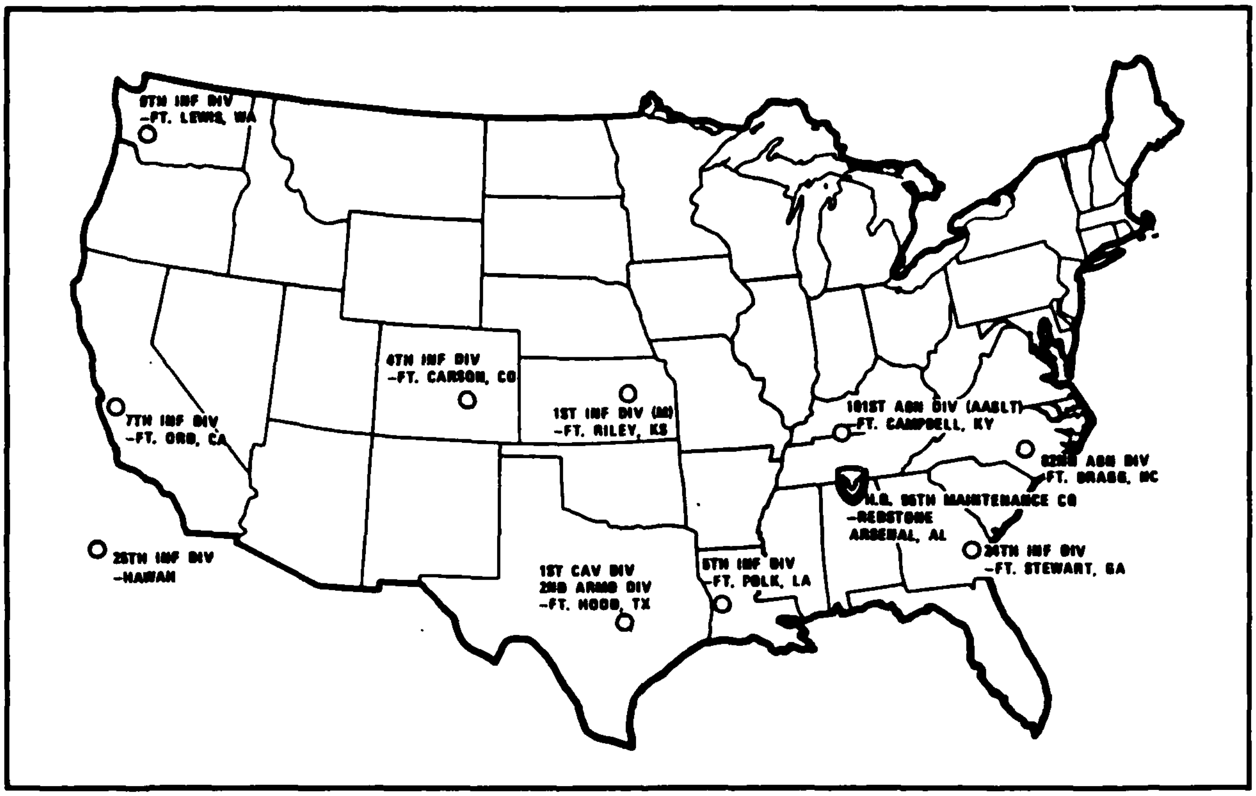


SOURCE: Michael C. Sandusky, Final Comprehensive Report on the U.S. Army Calibration Program, Vol. 1 (Alexandria, Virginia: Headquarters AMC, Office of the Deputy Executive Director for TMDE, July 1984).

at fixed sites or as mobile teams for on-site support. These ATSTs do not have a wartime deployment role.

The 95th Maintenance Company, in contrast, is a deployable TMDE support organization. It comprises an ACL and 17 ATSTs, with 1 or more attached to each CONUS division and the 1st Corps Support Command at Fort Bragg, North Carolina (Figure 3-4). In wartime, one ATST would deploy with each FORSCOM and National Guard division.

FIGURE 3-4. 95th MAINTENANCE COMPANY (TMDE) ATST LOCATIONS

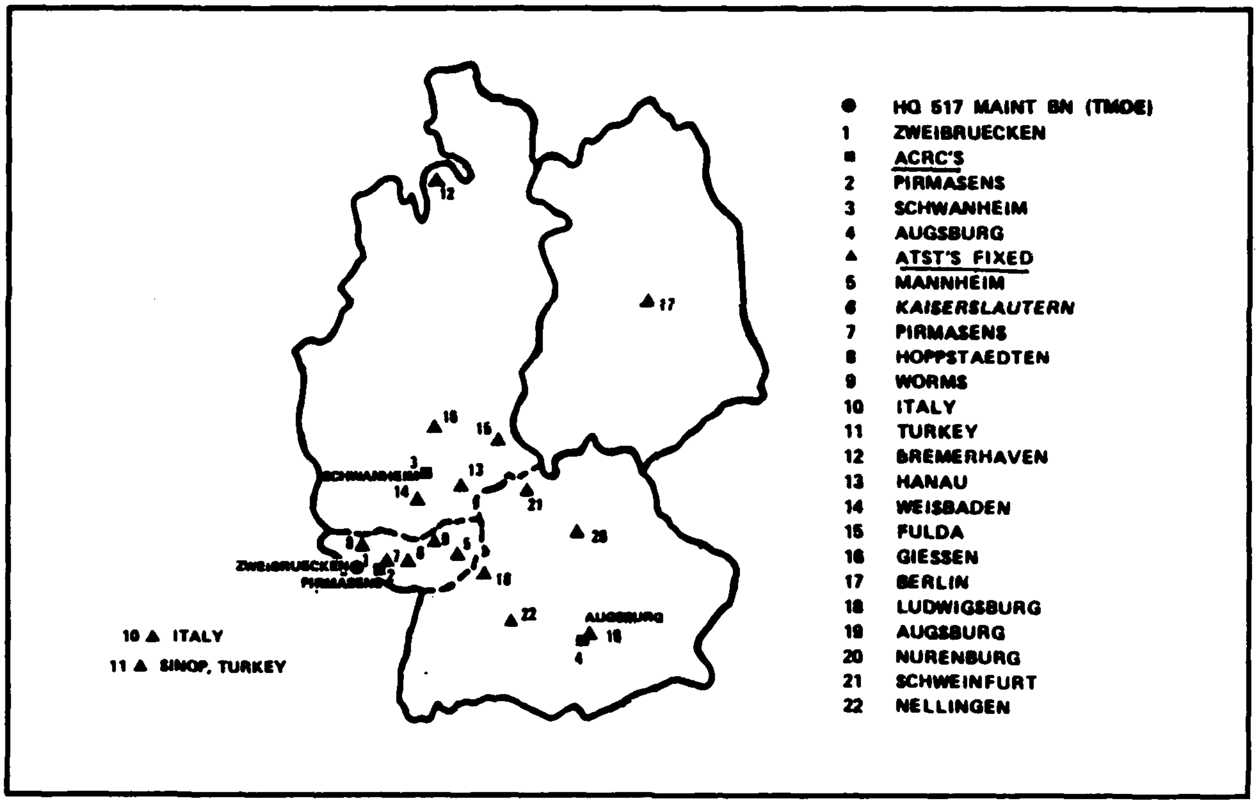


SOURCE: Michael C. Sandusky, Final Comprehensive Report on the U.S. Army Calibration Program, Vol. 1 (Alexandria, Virginia: Headquarters AMC, Office of the Deputy Executive Director for TMDE, July 1984).

Overseas TMDE support is provided by the 517th Maintenance Battalion (TMDE), with headquarters at Zweibrücken, Federal Republic of Germany; and the 74th Maintenance Battalion (TMDE), with headquarters at Camp Market, Republic of Korea. The 517th is assigned three companies, one for each corps (V Corps and VII Corps) and one for the theater support command

(21st Support Command). Each company has one ACL located at company headquarters and several ATSTs that operate either at fixed sites or as mobile teams visiting supported units at 120-day intervals. (Calibration intervals of Army TMDE are in multiples of 120 days currently, with studies in progress to extend these intervals to 180-day multiples.) A total of 45 ATSTs operate at or from the 21 sites shown in Figure 3-5. The area support concept used in peacetime would revert to a unit-alignment concept in wartime, with fully mobile ATSTs attached to division support commands, Corps Support Commands, and Theater Army Area Commands.

FIGURE 3-5. <u>517th MAINTENANCE BATTALION (TMDE), EUROPE</u>

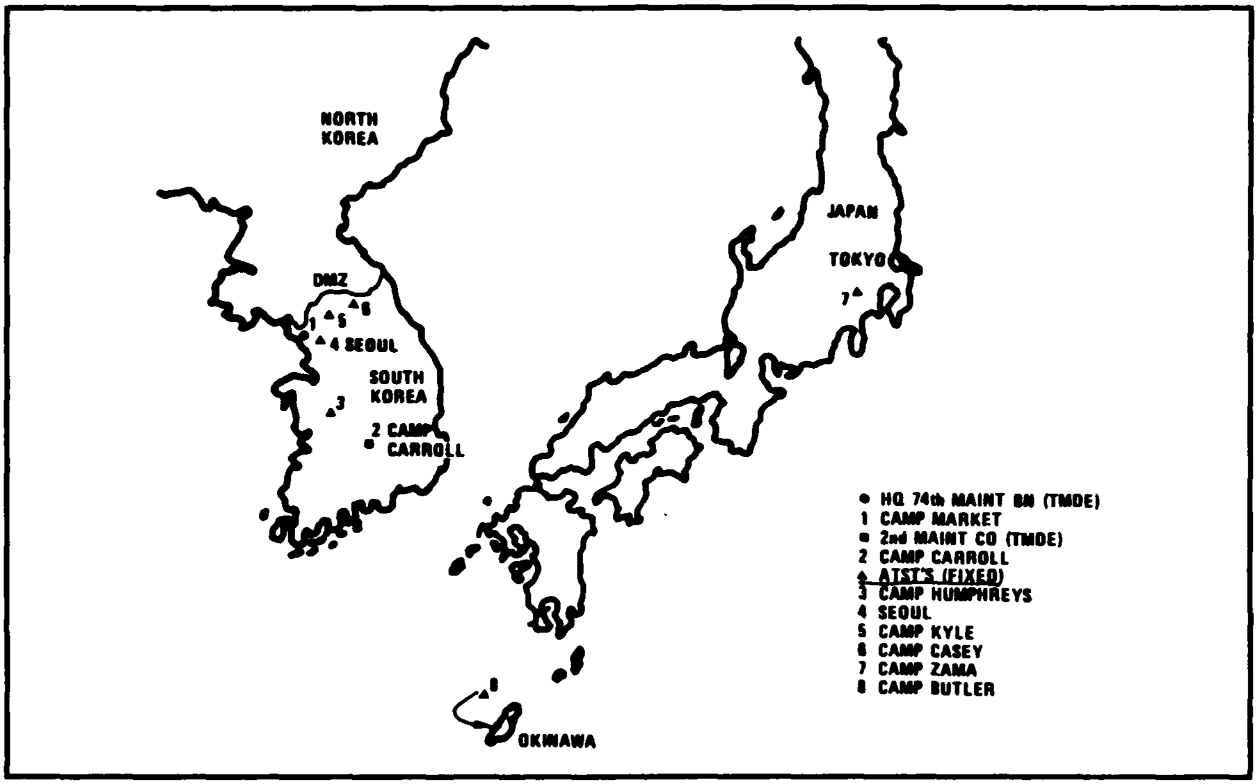


SOURCE: Michael C. Sandusky, <u>Final Comprehensive Report on the U.S. Army Calibration Program</u>, Vol. 1 (Alexandria, Virginia: Headquarters AMC, Office of the Deputy Executive Director for TMDE, July 1984).

The primary mission of the 74th Maintenance Battalion (TMDE) is to support the 2nd Infantry Division in Korea. It has only one maintenance company with one ACL, located at Camp Carroll, Korea, and 14 ATSTs located in Korea, Japan, and Okinawa (see Figure 3-6). The battalion

also has three ATSTs to provide support to the Western Command and the 25th Infantry Division in Hawaii.

FIGURE 3-6. 74th MAINTENANCE BATTALION (TMDE), PACIFIC



SOURCE: Michael C. Sandusky, Final Comprehensive Report on the U.S. Army Calibration Program, Vol. 1 (Alexandria, Virginia: Headquarters AMC, Office of the Deputy Executive Director for TMDE, July 1984).

The Army has 140 ATSTs, 61 of which are staffed with civilian and 79 with military personnel. Each team is equipped with a secondary transfer standards set in an expansion van, mounted on a 5-ton, 10-wheel truck. The set comes in two configurations – AN/GSM-286 (consisting of direct current/low-frequency and physical standards) and AN/GSM-287 (same as AN/GSM-286 supplemented with additional standards, including microwave, in a second truck-mounted van). Each team is mobile, with power provided by a trailer-mounted generator. The AN/GSM-286 team has five billets, four of which are calibration specialists. The AN/GSM-287 team is authorized

seven billets, including six calibration specialists; in addition, a warrant officer is authorized for every three teams to serve as a supervisor.

The overseas ATSTs and ACLs are augmented by civilians (TDA augments or contractors). The extent of augmentation is shown in Table 3-2. The organizations above the horizontal line in the table do not have a deployment mission, while those below have such a mission. The term "technician" refers to those military and civilian personnel doing hands-on work, excluding administrative, supply support, and other overhead personnel. The entry for the Army National Guard refers to the TMDE support activities located at Combined State Maintenance Shops (CSMSs). (About 20 percent of TMDE calibration/repair workload is beyond the National Guard's capability and is performed by USATSAC, except in Puerto Rico where the excess workload is performed by the Navy under an ISSA.) As shown in the table, the overseas TMDE support units make extensive use of civilians to perform their workload. Moreover, most are contractors or local nationals. (The latter category includes direct hires, indirect hires through host nation support agreements, and Civilian Support Group personnel that are quasi-military personnel.)

The actual use of "nonorganic" personnel to calibrate and repair TMDE is even more prevalent than shown in Table 3-2. A recent Army audit revealed that approximately two-thirds of the TMDE repair workload is being performed by the nonorganic personnel, who comprise only 17 percent of total staffing.[4]

More recent data (May 1985), show that the 517th Maintenance Battalion is now supported by about 130 "nonorganic" personnel as follows:

- Department of the Army civilians: 9
- Civilian Support Group: 26
- Local nationals: 54

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[4]U.S. Army Audit Agency, Report of Audit: Test, Measurement, and Diagnostic Equipment Support, U.S. Army Europe and Seventh Army, Audit Report EU85-201 (Alexandria, Virginia: Department of the Army Office of the Auditor General, 10 October 1984).

TABLE 3-2. USE OF CIVILIANS IN U.S. ARMY TMDE CALIBRATION/REPAIR SUPPORT

TYPE OF CALIBRATION ACTIVITY	CIVILIAN TECHNICIANS		MILITARY TECHNICIANS	
	Authorized	On-Hand	Authorized	On-Hand
Primary Standards Laboratory	36	33	4	4
ACRCs under USATSAC	279	265	45	79
ICRCs under USATSAC	63	56	46	55
AGMC Internal Facilities	363	321[a]	38	34
Army National Guard (CSMS)	148	130	0	0
95th Maintenance Co., Redstone Arsenal[b]	0	0	123	199
517th Maintenance Bn (TMDE), Germany[b]	62	59[c]	265	297
74th Maintenance Bn (TMDE), Korea[b]	36	36[d]	82	101
TOTAL	987	900[e]	603	769

[a]Includes 50 contractor personnel.

[b]Units with wartime deployment mission for TMDE support.

[c]Includes 27 contractor personnel, 14 local nationals, and 18 Civilian Support Group personnel.

[d]Includes 14 local nationals and 12 contractor personnel; only the TMDE support detachment in Hawaii uses Department of the Army civilians.

[e]Includes 89 contractor, 28 local national, and 18 Civilian Support Group personnel.

SOURCE: Michael C. Sandusky, Final Comprehensive Report on the U.S. Army Calibration Program, Vol. 1 (Alexandria, Virginia: Headquarters AMC, Office of the Deputy Executive Director for TMDE, July 1984).

- Federal Electric, Inc.: 31 (25 supporting the 517th and 6 performing TMDE support for the Area Maintenance Support Facility at Mannheim)
- Three other contractors supporting the test equipment for specific systems
- NATO [North Atlantic Treaty Organization] Maintenance and Supply Activity (NAMSA): 6.

The recent reorganizations of TMDE support in Europe, including the consolidation of calibration and repair under the U.S. Army TMDE Support Activity Europe in October 1979 and the conversion of that TDA unit into the 517th Maintenance Battalion on 1 February 1983, have reduced backlogs from a peak of 8,000 items in June 1981 to around 2,000 in 1984 and shortened repair turnaround times from 60 days in April 1981 to the mid-20s in 1984. Both of these improvements,

however, can be traced to the performance of nonorganic personnel. According to personnel from the 517th, elimination of those nonorganic personnel would necessitate an increase of 118 enlisted personnel. An additional 40 technicians would be required if contractor support for the fielding of new equipment were also eliminated.

A recent study conducted by USATSG, using a simulation model, concluded that the Army's TMDE support requirements in wartime could be accommodated by 142 ATSTs (75 AN/GSM-286 and 67 AN/GSM-287) rather than the 215 previously estimated.[5] The reduction resulted from a more precise estimate of wartime workload, consolidating nondivisional microwave calibration support, and introducing automation of meter calibration. (Multimeters and voltage meters account for 28 percent of the Army's TMDE inventory.) The Army is now planning a phased modernization of its present inventory of 143 AN/GSM-286 and AN/GSM-287 sets to replace obsolete equipment, add instrument controllers, and include automated meter calibration.

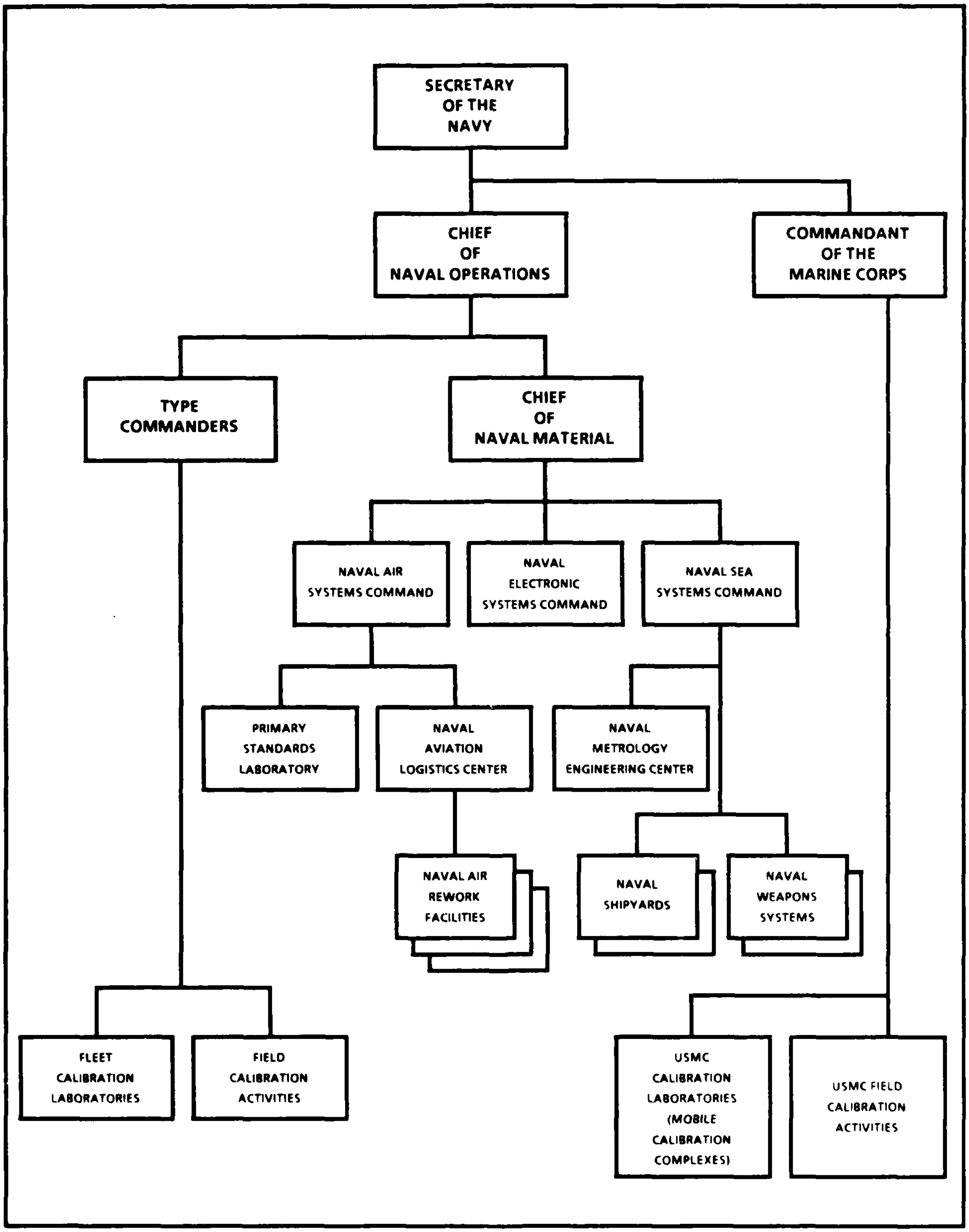
Navy

ETE support in the Navy is divided between owning organizations, which have the primary repair responsibility, and calibration laboratories or activities, which calibrate the ETE. If the repairs are beyond the capability of the owning organization, then that organization requests assistance from activities that can perform the repairs, such as tenders, Naval Shipyards, Weapons Stations, or NARFs.

The Navy organization for calibrating ETE is much more formal than its organization for repairing it (see Figure 3-7). Type Commanders, such as the Commander, Naval Air Forces Atlantic, or Commander, Naval Surface Forces Pacific, are assigned responsibility for Fleet calibration laboratories. These laboratories are located aboard tenders, repair ships, and other ships with intermediate-maintenance capabilities (such as carriers) and are also located ashore at SIMAs and Aircraft Intermediate Maintenance Departments. Calibrations performed by these laboratories

[5]Michael C. Sandusky, Final Comprehensive Report on the U.S. Army Calibration Program, Vol. 1 (Alexandria, Virginia: Headquarters AMC, Office of the Deputy Executive Director for TMDE, July 1984).

FIGURE 3-7. NAVY ETE SUPPORT



are managed using MEASURE. Under this system, equipment is called in for calibration automatically at scheduled calibration intervals. (The Army and Air Force have comparable recall systems for managing and monitoring calibration.) Type Commanders are also responsible for Type IV Fleet Calibration Activities that are operated by many units for organizational support of their own test equipment. Both types of laboratories perform repairs incidental to the calibration, usually those that can be accomplished within 1 hour and require no material. The Marine Corps calibrates its own equipment using either calibration laboratories installed in mobile calibration complexes or field calibration activities.

Quantitative data on the support of test equipment were not available from the Navy. However, several interviews were conducted for purposes of obtaining an overview of the effectiveness of test equipment calibration and repair support in the Navy. Among those interviewed were Type Commanders, representatives from two destroyer squadrons, and supervisory personnel from tenders and SIMAs.

The Type Commanders believe that test equipment management in the Navy needs to be improved. They are missing some test equipment; the repair pipelines are excessive; and some of the ATE is antiquated and unsupportable (one example mentioned was the AN/AWM-23, which supports the F-14 radar). They also stressed the increasing need for repair support because of a dramatic increase in damaged or abused general-purpose test equipment received at calibration facilities. (This problem, attributed to inadequately trained personnel, was first called to the attention of the Chief of Naval Technical Training by the Commander in Chief, Atlantic Fleet in late 1981.[6])

The destroyer squadron staff observed that management of ETE is "out of hand." On the East Coast, calibration requests are normally submitted via the Readiness Support Group (Norfolk) to a tender or SIMA, but those requests are rejected when the ETE is not operable. There is no replacement system for ETE that cannot be economically repaired. Furthermore, repair activities

[6]Commander in Chief, Atlantic Fleet message to Chief of Naval Technical Training, Subject: "Training of Technical Ratings for Fleet Maintenance," date time group 071410Z, October 1981

may dispose of ETE if they cannot economically repair it, but they do not notify the ship that they have taken such an action. When the ship finds that the equipment has been disposed, it has to procure replacement ETE using its own limited funds. The destroyer squadron staff also noted that deploying ships never have all of their test equipment allowance aboard, even after obtaining as much as possible from other ships. They are invariably 10 to 30 items short, with most of those being low-density items (those for which the ship is authorized only 1 or 2). The missing items affect the crew's ability to perform planned maintenance while underway because the maintenance requirements cards specify particular ETE. Although it is frequently possible to perform the maintenance using substitute ETE, that approach requires special skills that may not be available. Finally, the destroyer squadron staff also noted that approximately 70 percent of its GPETE is obsolete and needs to be replaced.

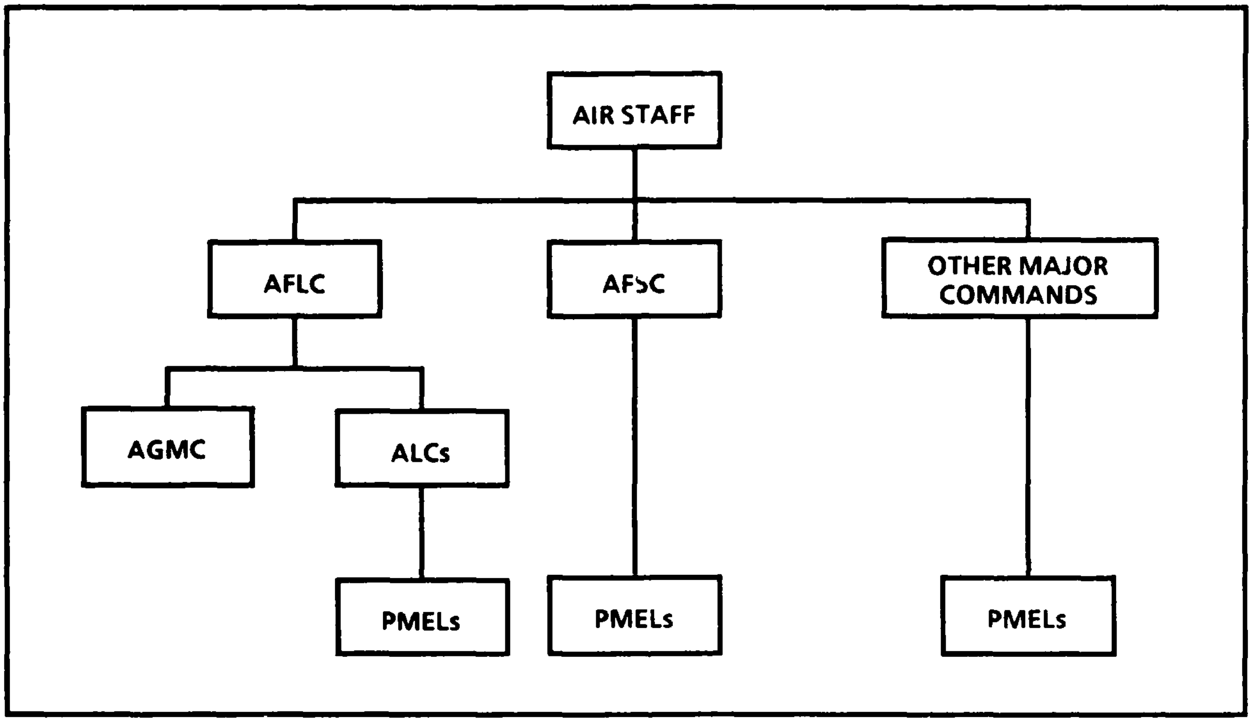
The tender personnel stated that the turnaround time for GPETE repair typically averages 30 days, while that for special-purpose ETE, which goes to a shore-based repair facility or depot, frequently is as long as 1 year. They also noted that the surface Navy does not have a technical training course, as the air community does, for the training of test equipment repair. Any "A" School graduate in one of the technical ratings who completes the tri-Service calibration course at Lowry Air Force Base, Colorado becomes a calibration/repair technician without further training. (In the Navy, NARFs provide a 2-week course for ETE repair.)

Air Force

The Air Force's test equipment support management structure is straightforward, as shown in Figure 3-8. The Metrology Division of AGMC is the central Air Force authority for calibration procedures, schedules, and equipment. It operates the Air Force Measurements Standards Laboratory, the Air Force's Type I laboratory, and it exercises technical direction and evaluation authority over all Air Force PMELs. The major Air Force commands are responsible for maintaining and operating PMELs at selected bases and installations to calibrate, certify, and repair all common and designated peculiar test equipment of the host, tenant, and off-base supported Air Force activities, including the Air National Guard and Air Force Reserve. They are also responsible

for operating programs for PME scheduling and maintenance data collection and for assisting supported activities with the calibration and repair of peculiar PME (not specified as a PMEL responsibility).

FIGURE 3-8. AIR FORCE PME SUPPORT



In addition to the PMELs supporting the operating forces, AFLC operates PMELs that are dedicated to the support of its depot activities (one PMEL per ALC) and AFSC operates the special PMELs for in-house dedicated support to its research, development, test, and evaluation activities. The responsibilities of AFSC and AFLC during the acquisition process to ensure that test equipment, calibration procedures, and calibration equipment will be available are described earlier in this report.

The 134 Air Force PMELs are authorized 3,100 personnel; if the major command functional area managers, the Air Training Command PMEL school at Lowry Air Force Base, the logistics personnel at AFSC and AFLC, and AGMC personnel are included, then the total METCAL community numbers slightly over 4,000 people. Volume II of this report describes the Air Force's

1981 improvement program that focused on modernization of PMEL equipment, improvement of management procedures, and initiatives in the personnel area.

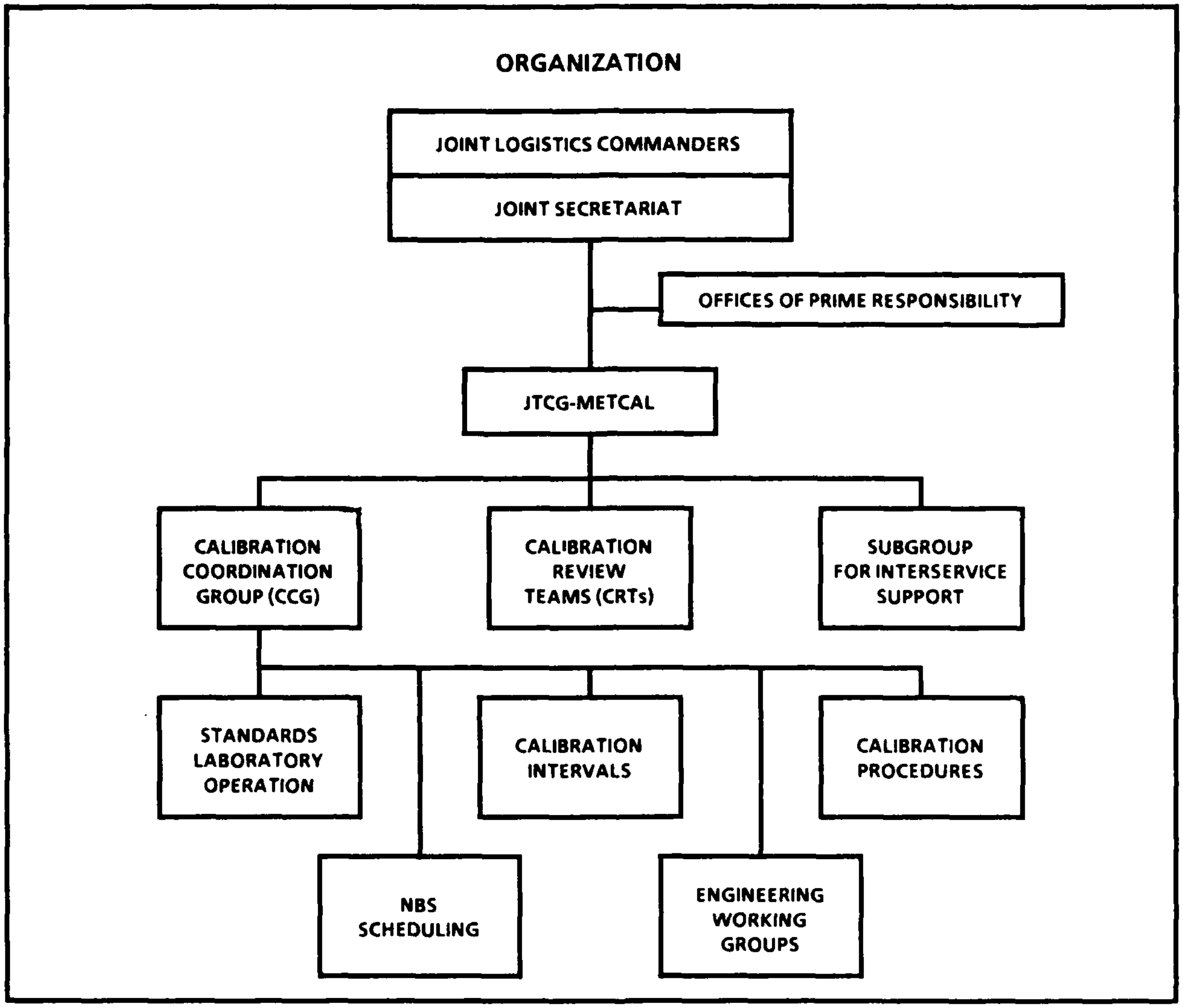
Interservice Support

The organizational structure of the Joint Technical Coordination Group for Metrology and Calibration (JTCG-METCAL) is shown in Figure 3-9. Since 1976, the JTCG-METCAL has sponsored a number of consolidation studies. One study addressed the feasibility of consolidating the Type I laboratories, others focused on the economics of consolidating calibration activities in regional areas without degrading mission capabilities. Such studies have been performed for the Tidewater/ Norfolk area, Philadelphia area, Washington, D.C. area, Northwest area, California, and Europe. Few of the recommendations for consolidating calibration activities have been implemented, however. The study of European activities illustrates some of the difficulties of implementing those types of recommendations.

That study, "Consolidation of DoD Calibration Activities in Europe," was conducted in response to a U.S. Commander in Chief, Europe request in October 1975 that the Army convene and chair an ad hoc study group, with Air Force and Navy representation, to determine the feasibility and advisability of establishing consolidated calibration facilities within the European Theater. The ad hoc group was established in November 1975 and requested support from JTCG-METCAL. In January 1976, the Consolidation of Calibration Services Subgroup met with the ad hoc group and agreed to perform the study that was subsequently completed in September 1976. The subgroup recommended a concept of two consolidated calibration laboratories in the Federal Republic of Germany (FRG):

- Consolidation of Air Force PMELs at Hahn and Bitburg Air Bases into one expanded PMEL at Ramstein Air Base.
- Consolidation of Army ACRCs at Pirmasens and Augsburg into one expanded ACRC at Schwanheim. (The report noted that Schwanheim was not the optimal location and recommended that another site for this single Army laboratory be selected.)
- Implementation of ISSAs between the Air Force and the Army, with the Air Force assuming the Army's calibration workload in the Kaiserslautern, FRG area, Italy, and Turkey and the Army assuming the Air Force's calibration workload in the Frankfurt-Würzburg, FRG area, using its ATSTs.

FIGURE 3-9. ORGANIZATION CHART JTCG-METCAL



SOURCE: Fred B. Seeley (DARCOM Member), Joseph T. Siedlecki (NMC Member and Chairman), Seldon W. McKnight (AFLC Member), and Major M. J. Murtaugh (AFSC Member), "Study Plan Joint Technical Coordinating Group on Metrology and Calibration (JTCG-METCAL)," Unpublished Working Paper, 22 November 1982.

The present value of savings (equipment/facility costs plus annual personnel, transportation, and support costs) on a 5-year discounted basis was estimated at $3 million. Importantly, the subgroup examined the potential of NAMSA providing calibration support, but determined that such support would not be economic. The cost comparison, however, was made between a fully loaded hourly rate of NAMSA (including burden, general/administrative, and overhead expenses) and direct

charges of DoD Components (excluding those indirect expenses). As indicated, the recommended consolidations were never implemented.

Observations

In comparing the different management approaches to test equipment support, one striking difference is the extent of control exercised by the user, i.e., commanders of the operating forces. While calibration of test equipment is offered as a "free service" to the user throughout the DoD, the user has no control in the Army, some in the Navy, and a significant amount in the Air Force.

The Army has made great progress in recent years toward improving its calibration and repair support of common ETE. Although there may yet be some unresolved problems, the Army has overcome most of its test equipment support shortfalls. The Air Force has also made progress by firmly addressing the PMEL problems that resulted primarily from neglect. In comparison, the Navy has not significantly improved test equipment support in the Fleet.

ATE CALIBRATION AND REPAIR

The nature and extent of the problems associated with ATE support have been well documented in numerous studies. The Joint Logistics Commanders (JLC) Panel on Automatic Testing sponsored an effort by the NBS to "determine and develop concepts (policies, standards, techniques, practices, and procedures) for on-line and off-line calibration to verify performance of the DoD family of ATE, with special emphasis to be placed on performance verification of third-generation and later generations of ATE." However, after 1 year, that effort was terminated because of lack of funding.[7]

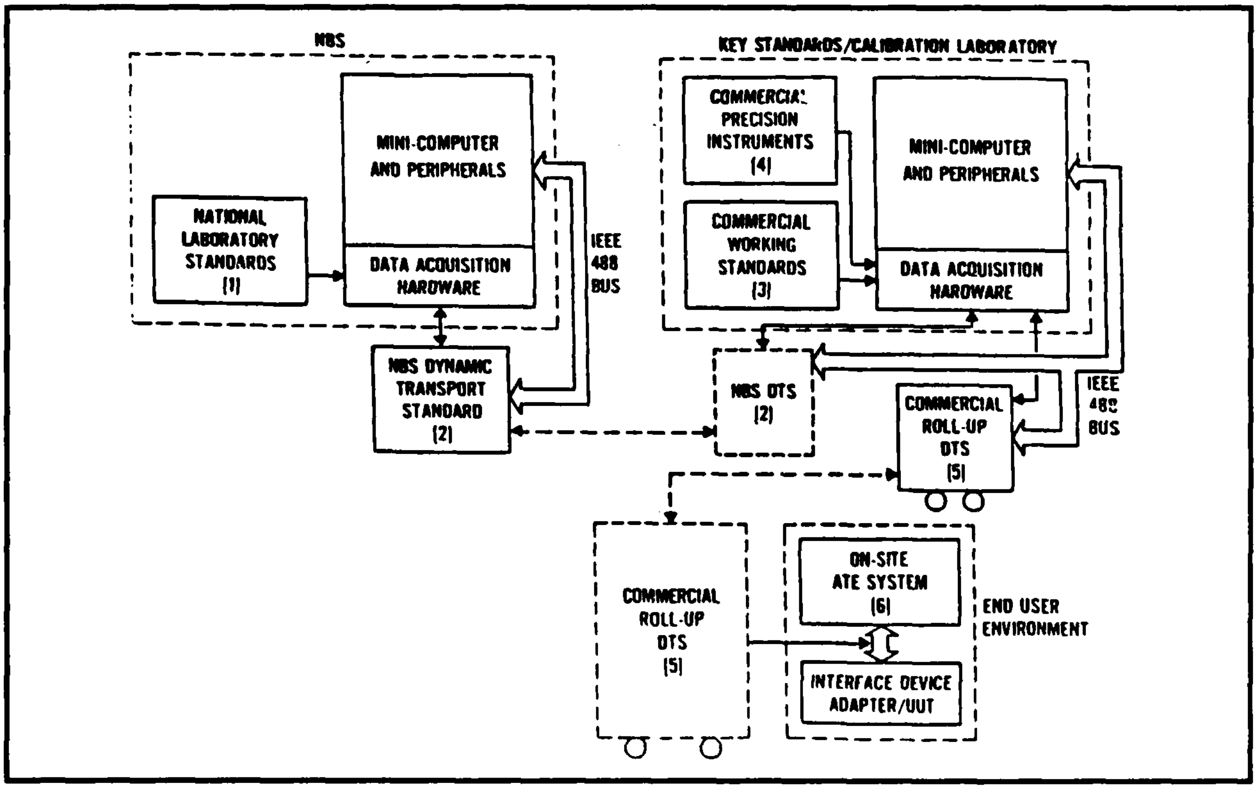
The NBS study included a limited experimental investigation of the measurement performance of two ATE stations. The results showed erratic measurements, distorted signals, large measurement errors (departures from nominal values), and other shortcomings. At the same time, the results demonstrated both the need for, and the viability of, on-site dynamic testing of ATE

[7]Barry A. Bell, et al., Automatic Test Equipment Calibration/Performance Verification Evaluation and Research Program, NBSIR82-2601, Parts I and II (Washington, D.C.: U.S Department of Commerce, December 1982).

system performance characteristics at the stimulus/measurement interface connector, using calibrated "dynamic transport standards" (DTS).

The NBS recommended development of an ATE calibration approach. That approach is illustrated in Figure 3-10. ATE systems would be tested and calibrated on site with a commercial DTS configured as a calibration console for a particular class of ATE (Item 5). The commercial DTS would periodically be calibrated at a (military) calibration or standards laboratory using the NBS DTS (Item 2), the laboratory's working standards (Item 3), and calibrators (Item 4). The NBS DTS, in turn, would be periodically calibrated at the NBS.

FIGURE 3-10. NBS PROPOSED CONCEPT OF DYNAMIC TRANSPORT STANDARDS (DTS) TO SUPPLEMENT PRESENT ATE CALIBRATION SYSTEMS



SOURCE: National Bureau of Standards, Automatic Test Equipment Calibration/Performance Verification Evaluation and Research Program, NBSIR 82-2601, Part II (Washington, D.C.: U.S. Department of Commerce, December 1982).

In its report, the NBS outlined a long-term research and development program to develop a capability for supporting present and future ATE systems used by DoD, noting that the "current

system is not adequate to develop standards and traceability requirements for state-of-the-art ATE used by DoD." JLC support of this program was terminated in 1982.

PEACETIME VERSUS WARTIME SUPPORT

The adequacy of present test equipment support capabilities is difficult to ascertain because the Military Services, with one exception, do not collect or monitor data on the availability of operable test equipment at the using maintenance units. (The exception is San Antonio ALC's ATE management information system.) The Joint Chiefs of Staff Unit Status Reporting System is primarily designed for combat units rather than maintenance units, so test equipment is not considered a reportable, pacing item. The data bases established by the METCAL organizations are designed to monitor calibration intervals, not test equipment availability. Similarly, the developing management information systems for test equipment are designed primarily to track inventory status.

One of the primary performance indicators for calibration and repair shops is turnaround time (TAT). The available data suggests that substantial progress is being made to reduce TAT, particularly by the Army in Europe where the average repair TAT of 60 days in March 1981 reduced to 26 days by September 1984. Similarly, the average calibration TAT was 9 days in March 1981 and was reduced to 5 days in September 1984.

Although some of the major shortfalls have been addressed, two ETE support problems remain: (1) shortages of experienced technicians (e.g., over 60 percent of the PMEL work force in the Air Force has less than 4 years of experience, the Army's 517th Maintenance Battalion claims it is 158 enlisted personnel short of those necessary to perform its mission under current operating conditions without contractor support) and (2) shortages of spare parts. The latter is one of the primary reasons for excessive TAT for test equipment repair.

Overall, test equipment support may be considered adequate to meet peacetime readiness requirements, but its capability to meet wartime sustainability requirements is questionable, primarily because the Military Services have not published policies or plans for wartime test equipment support. Some of the Army's ACRC supervisors speculate that in wartime all scheduled calibrations would be stopped and that, after a resulting short dip in the workload, test equipment repair

workload would sharply increase from peacetime levels. They believe that the result would be excessive TATs because of shortages of spare parts and the inability to compensate because the supported maintenance units do not have float equipment. In contrast, some Air Force PMEL technicians assert that scheduled calibrations of test equipment will become even more important to ensure peak performance of supported weapons systems, with little change in the mix (calibration versus repair) but a steep increase in the total workload. The Navy and Marine Corps calibration activities did not speculate on their wartime workload.

Looking at the issue of wartime test equipment support strictly from a metrology point of view, the much more intense use of test equipment would mandate decreasing the calibration intervals to maintain the same within-tolerance rate as in peacetime. As a result, calibration workload, provided scheduled calibrations continue, would increase sharply, especially in the Army. Separate calibration intervals for wartime, however, have not been established by any of the Military Services. More importantly, if the peacetime calibration intervals are adhered to under wartime operating tempos, the within-tolerance rate of test equipment would plummet to a level at which the test equipment could not be used in weapons system maintenance.

MANAGEMENT AND SUPPORT OF CALIBRATION EQUIPMENT

As noted in Chapter 1, this study does not extend to the management and support of calibration equipment but rather is limited to test equipment used in weapons system maintenance. Nevertheless, calibration equipment is merely another category of test equipment, and a number of issues related to calibration equipment warrant additional attention: (1) the potential for much more consolidation than has been achieved over the past years; (2) the monitoring of the materiel condition of calibration standards; (3) the modernization, including automation, of calibration equipment; (4) Joint Service standardization of calibration procedures, calibration equipment, and calibration intervals, including those for modern ATE; and (5) the lag in research and development funding for metrology and calibration. Many of these issues appear to warrant attention by the JTCG-METCAL.

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4. ACQUISITION AND SUPPORT OF TEST PROGRAM SETS

This chapter describes the TPS acquisition process and the procedures used in the development and life cycle support of test programs. Its purpose is to discuss some of the factors that may explain the problems in developing and fielding TPSs and to point to areas in need of increased emphasis.

BACKGROUND

TPSs represent a unique category of test equipment because they consist primarily of software, not hardware. Although TPSs are essential to the weapons system support mission of the ATE, there is no consensus on whether the DoD directive pertaining to the management of computer software, other than general-purpose commercial automatic data processing, resources (DoD Directive 5000.29, "Management of Computer Resources in Major Defense Systems," 26 April 1976) does or should apply to TPSs.

TPS is defined in MIL-STD-1309C as follows:

> The combination of operational test program, operational test program instruction, and interconnection device or signal conditioning circuitry that together allow an ATE/TMDE to perform the test necessary to check and diagnose a UUT [unit under test].

Test programs are used both in the manufacturing process and in field service to enable automatic testing for quality control (manufacturing) and for fault diagnosis of replaceable assemblies and modules (maintenance). The traditional test philosophy for automatic testing in the DoD maintenance environment is known as "functional or performance testing."[1] In the commercial

[1]Functional test is defined as follows: "A test which determines whether the UUT is functioning properly. The operational environment (such as stimuli and loads) can be either actual or simulated" (MIL-STD-1309C). Functional testers gain access to the UUT via the edge connector of the circuit board, so that the interconnection device is normally simple. Functional tests can be either static (whereby UUT output measurements are made only after they have stabilized with respect to a given input stimulus, i.e., at low speed) or dynamic (whereby the testing sequence is performed at the UUT's rated speed). The choice between the two is based on cost effectiveness.

maintenance environment, "in-circuit testing" is more frequently used.[2] A mix of these two approaches is used in the manufacturing process with in-circuit testers (in conjunction with other quality control methods) applied at the lower levels of indenture (piece parts, circuit boards) and functional testers at the higher levels of indenture (circuit boards, assemblies). Testing at the sub-system and system levels in the manufacturing plant is generally a manual operation, using either hot mockups or the weapons system itself with its built-in test (BIT). The testing philosophy has a strong impact on the cost of testers and associated test programs. A rough comparison is shown in Table 4-1. Manufacturers are, therefore, vitally interested in determining the most cost-effective mix of automatic testing applications in their production line as a function of volume, fault spectrum, and yield at each stage of production.

TABLE 4-1. COMPARISON OF AUTOMATIC TESTING PHILOSOPHIES

CRITERIA	IN-CIRCUIT TEST	FUNCTIONAL TEST
Cost of ATE	Low	High
Set-Up Costs		
• Programming	Low	High
• Fixtures	High	Low
Testing Costs (go/no-go)	High	Low
Diagnosis Costs	Low	High
Repair Costs of UUT	Low	High
Fault Coverage (affects inversely the next stage test cost)	Low	High

SOURCE: Brendan Davis, The Economics of Automatic Testing (London: McGraw-Hill Book Company, Ltd., 1982).

[2]In-circuit test is defined as follows: "Tests of individual components within a circuit while guarding out the effects of surrounding components (analog) or overriding (digital) inputs" (MIL-STD-1309C). In-circuit testers require bed-of-nails fixtures to gain access to test points on the circuit board; such fixtures are complex and costly compared to the interconnection devices normally required for functional board testers.

In recent years, technology advances have weakened the traditional distinctions outlined above. For example, the commercial ATE industry is starting to combine the two test approaches into ATE designed to do both in-circuit and functional testing. The simpler versions of those testers use a split approach, with in-circuit testing for analog circuitry and functional testing for digital circuitry. The more complex versions provide a full in-circuit testing and functional testing capability in the same mainframe. However, their high cost limits them to special-purpose performance-testing applications. The use of two separate testers has become standard practice, with in-circuit testers used as a screening device for manufacturing defects or damage and functional testers used for evaluating functional performance and diagnosing faults. Another recent development in the ATE industry is the adoption of a new testing philosophy for microprocessor boards. The approach, known as "in-circuit emulation," has become popular because it overcomes the limitations of digital in-circuit testers (such as the inability to detect critical logic timing faults, inability to test circuitry interaction, and limited ability to perform dynamic testing) without incurring the disadvantages of functional testers (including high ATE costs, high programming costs, and fault isolation ambiguity).[3] With most of today's digital circuit boards containing a microprocessor, the in-circuit emulation test approach can be expected to become the standard test philosophy in the commercial sector for field service of digital boards. In the military sector, however, this approach cannot be applied because circuit boards are generally designed to military specifications that presently require them to be hard-wired, thereby prohibiting the use of plug-in microprocessors.[4]

Other trends in automatic testing are being driven by technology advances in prime equipment that result in ever-increasing component density. The industry adoption of "surface mount

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[3]For a general description of in-circuit testing and in-circuit emulation techniques and equipment, see: John Bateson, "In-Circuit Testers for Service and Repair", Evaluation Engineering, July 1984, or the same author's book, In-Circuit Testing (Florence, Kentucky: Van Nostrand Reinhold Co., Inc., 1985).

[4]One DoD document that advocates using sockets for complex integrated circuits, is a recent Air Force design guide: Directorate of Support Systems Engineering, "Onboard Test (OBT) Improvement Project – Phase II," ASD-TR-83-5012 (Wright-Patterson Air Force Base, Ohio: Aeronautical Systems Division, Air Force Systems Command, September 1983).

technology" to permit higher component density on a circuit board makes in-circuit testing of those components impossible (in-circuit testing can still be applied to the buses and controls of such boards), so that functional testing will be a requirement, not an option, in the manufacturing process. The impending introduction of very-high-speed integrated circuit technology and the impact of that technology on ATE requirements unknown at the present time, but such circuits will require functional testing.[5]

In sum, the traditional dichotomy between automatic testing requirements/techniques in the manufacturing plant and those for field service is beginning to disappear, with a convergence to the same testing technique (functional testing). Consequently, the opportunity for integrating, or coordinating, the development of test programs required in weapons system production and maintenance is increasing. Exploiting that opportunity would reduce the cost for TPSs and shorten the time needed to develop them.

The remainder of this chapter is focused on the present TPS acquisition and support process in the Military Services. That process is totally divorced from that of the prime and subcontractors for their own automatic testing needs in the manufacturing process.

INTRODUCTION

The acquisition or development of TPSs is a complex process. In the past, little guidance was available to program (project) managers as an aid in managing the process effectively. Both industry and DoD had to cope with a shortage of expert test program designers. Automated support tools had to be developed to improve the productivity of test program designers and the quality of test programs; until the late 1970's, the absence or limited availability of such tools translated into high TPS development costs, especially those for line replaceable units (LRUs). Because of the high cost of this support element for a new weapons system and its late development, funding was invariably cut or deferred. In the absence of an effective evaluation of the "quality" of test programs (diagnostic performance as well as run time), notwithstanding design reviews and formal acceptance tests,

[5]For the ATE industry's viewpoint see, for example: "Military ATE," Evaluation Engineering, November 1985.

contractor incentives were not practical in TPS procurement; instead, TPSs were procured under "fixed-price" or "cost-plus" contracts. In most cases, these contracts were with prime contractors (to minimize program management problems and Government risks with integrating TPSs and ATE), which created more of a disincentive than incentive for high-quality TPSs. These sole-source contracts for TPS development tended to be costly because contractors tried to protect themselves against the risks involved, especially the uncertain availability of Government-furnished ATE and test articles (UUTs) and the uncertainty caused by ambiguous acceptance criteria.

Examples of recent exceptions to this long-standing practice are the Navy's competitive procurement of TPSs for the F/A-18, resulting in a significant reduction in acquisition costs (although it still remains to be seen whether this approach will improve the diagnostic performance and maintainability of the resulting TPSs), and the Air Force's recent practice to compete TPSs for shop replaceable units (with the responsible ALC frequently the winner based on cost). The Army has also routinely developed a portion of its TPSs for circuit boards in-house, using the organic capabilities developed at its Tobyhanna, Pennsylvania, and Sacramento, California, depots.

Operational test programs consist of three sections. The first, often referred to as the "preamble survey," is designed to check the availability and status of the stimulus and measurement instruments that will be invoked by the other two sections of the test program. It also checks whether the correct interconnection device has been mounted; whether it has been hooked-up correctly; and whether it is operable. The second, "go chain," performs an end-to-end functional test if no faults are present, but terminates with the first discrepancy detected. The third section, "no-go chain," has multiple entry points (from the second section) and is designed to isolate each functional discrepancy to one or more replaceable, physical elements (e.g., piece parts if the UUT is a circuit board or circuit boards if the UUT is a higher level assembly).

The last two sections, fault detection and fault isolation, can be implemented in different ways. For fault detection, the alternatives are to compare the measured UUT responses (after applying input signals through the edge connectors) either to stored response patterns or to the responses measured from a known good UUT. The former ("stored pattern functional testing") is the standard

approach for DoD test programs, whereas the latter ("dynamic reference testing") is more common in the commercial sector. For fault isolation, the alternatives are "fault dictionary" and "computer-guided probing." In the fault dictionary approach, diagnostic test routines enter a large data base and perform additional tests as indicated to match a given discrepancy and associated cause(s) that have been determined through prior analysis. Because of the existence of "equivalent faults" (faults responsible for the same response pattern that cannot be distinguished by any set of input patterns), the fault dictionary approach frequently results in an ambiguous diagnosis, with a list of possible causes of the detected failure symptom. In contrast, computer-guided probing is based on a fault model of the UUT with interactive probing instructions displayed on the ATE's graphic display. Backtracking through the circuit along a "bad" path, the model directs the operator to place a logic probe on selected test points. For each point probed, it reruns the test program, while monitoring the logic values sensed by the probe, until a device is found that has all good inputs but one or more bad outputs. Both approaches (fault dictionary and guided probe) are able to isolate only one fault at a time and require the isolated fault to be repaired before the process can be restarted to detect and isolate other possible faults in the UUT.

The Military Services have adopted the fault dictionary approach as the standard approach for their TPSs, whereas computer-guided probing is the preferred method in commercial applications. The main advantages of the fault dictionary approach are the speed of test program execution and the avoidance of ATE operator intervention (i.e., the approach is perceived as reducing the skill requirements compared to guided probing). To compensate for the resulting ambiguity of fault isolation, some fielded TPSs include (noninteractive) probing instructions either on the video display terminal or in the test program instruction. Military Service policies and practices, however, differ on this issue. For example, the Army's Aviation Systems Command has a policy that prohibits the ATE operator from accessing the inside of a UUT at the intermediate-maintenance level – a policy largely inspired by the limited training and experience of ATE operators in the Army and the need to minimize inadvertent LRU damage. Nevertheless, technology is driving the need for probing within a UUT in order to reduce fault isolation ambiguity: the increasing device and circuit board

complexity impose testing requirements beyond the test point access afforded by edge connectors, so that additional test points must be accessed for fault isolation.

The answer to this problem is to place more emphasis on design for testability. The consensus is that inadequate design for testability is the principal cause of many TPS performance problems. With the recent promulgation of the first military standard on testability,[6] the expectation is that design for testability will receive more emphasis and scrutiny in the weapons system acquisition process. Currently, TPS quality is measured in three ways:

- Fault Coverage or Fault Detection Rate. This metric is defined as the percentage of possible hardware failures detectable by the TPS. If the percentage is well below 100 percent (i.e., not detecting existing failures) or above 100 percent (i.e., indicating failures where none exists), the TPS loses much of its practical value and the user loses confidence in test results.

- Fault Isolation Resolution Level. This metric specifies the ambiguity of automated fault isolation, commonly expressed in terms of a series of percentages of detectable failures isolated to 1, 2, . . ., n removable items, where n is the maximum size of the ambiguity group. If failures are isolated by the TPS to a large ambiguity group, manual trouble-shooting is necessary.

- Run Time. This metric is the elapsed time for executing the TPS, normally measured for a complete end-to-end functional check for a UUT without a failure.

TPS development contracts typically include quantitative goals, not firm requirements, for the first two metrics. The third metric is normally not addressed, except for a reminder that minimum run time is desirable. TPS run time is counted in seconds for digital circuit boards; hours for complex assemblies such as LRUs. The two primary factors influencing both diagnostic performance and run time are design for testability and UUT-ATE compatibility. Additionally, run time is very much influenced by the experience of the TPS developer as well as the user's ability to modify fielded TPSs based on empirical data. For example, experience shows that TPS run time frequently can be reduced by 30 to 80 percent through rearranging the sequence of tests performed. As another example, the Air Force found that by using multiple entry points in the functional test section of TPSs for avionics

[6]MIL-STD-2165, "Testability Program for Electronic Systems and Equipment" (Washington, D.C.: Naval Electronic Systems Command, 26 January 1985). This military standard is "approved for use," only; it is not prescribed.

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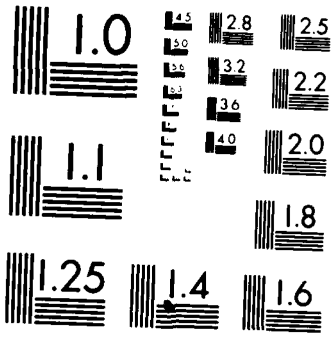
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1.4
1.6

LRUs (combined with recording fault codes displayed by BIT in the cockpit display), it did not have to double the ATE capacity in the F-16 avionics intermediate shop to support peacetime sortie rates as planned by AFSC. Unfortunately, such exploitation of BIT information at intermediate-level maintenance activities still remains an exception today.

TPS ACQUISITION

The specific policies and procedures for TPS acquisition differ among the Military Services, but the generic process consists of the following series of interrelated steps that are common to each:

- Test requirements specification
- Test requirements analysis
- TPS development
- TPS integration and acceptance test.

An overview of the generic process is provided by Figure 4-1, which happens to apply to the Air Force. A brief description of each of the above steps follows.

Test Requirements Specification

Development of the UUT test specifications is part of the design engineering and technical documentation effort; it is not included in the TPS development contract. In the absence of a DoD-wide standard, both the Air Force and Navy have adopted, independently, their own standards for the format, scope, and content of the formal documentation of this effort, known as the test requirements document (TRD).[7] The Army has not yet developed such a standard. Some of the basic problems with the timely specification of valid test requirements are described in the following subsections.

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[7]Air Force: MIL-STD-1519 (USAF), "Preparation of Test Requirements Document," 17 September 1971 (with Notice 1, 1 August 1977).

Navy: MIL-STD-1345B (Navy), "Test Requirements Document, Preparation of"; 10 February 1981, and MIL-STD-2076(AS), "Unit Under Test Compatibility with ATE, General Requirements for"; 1 March 1978.

Army: Design Standard for the Development of AN/USM-410 Test Program Sets, RCA Document CR-82-588-04, December 1982 (revised February 1984). This Army standard does not use the term TRD, but directs that "test specifications" be included in the "UUT data package," whenever possible.

FIGURE 4-1. TPS DEVELOPMENT AND MAINTENANCE PROCESS (AIR FORCE)

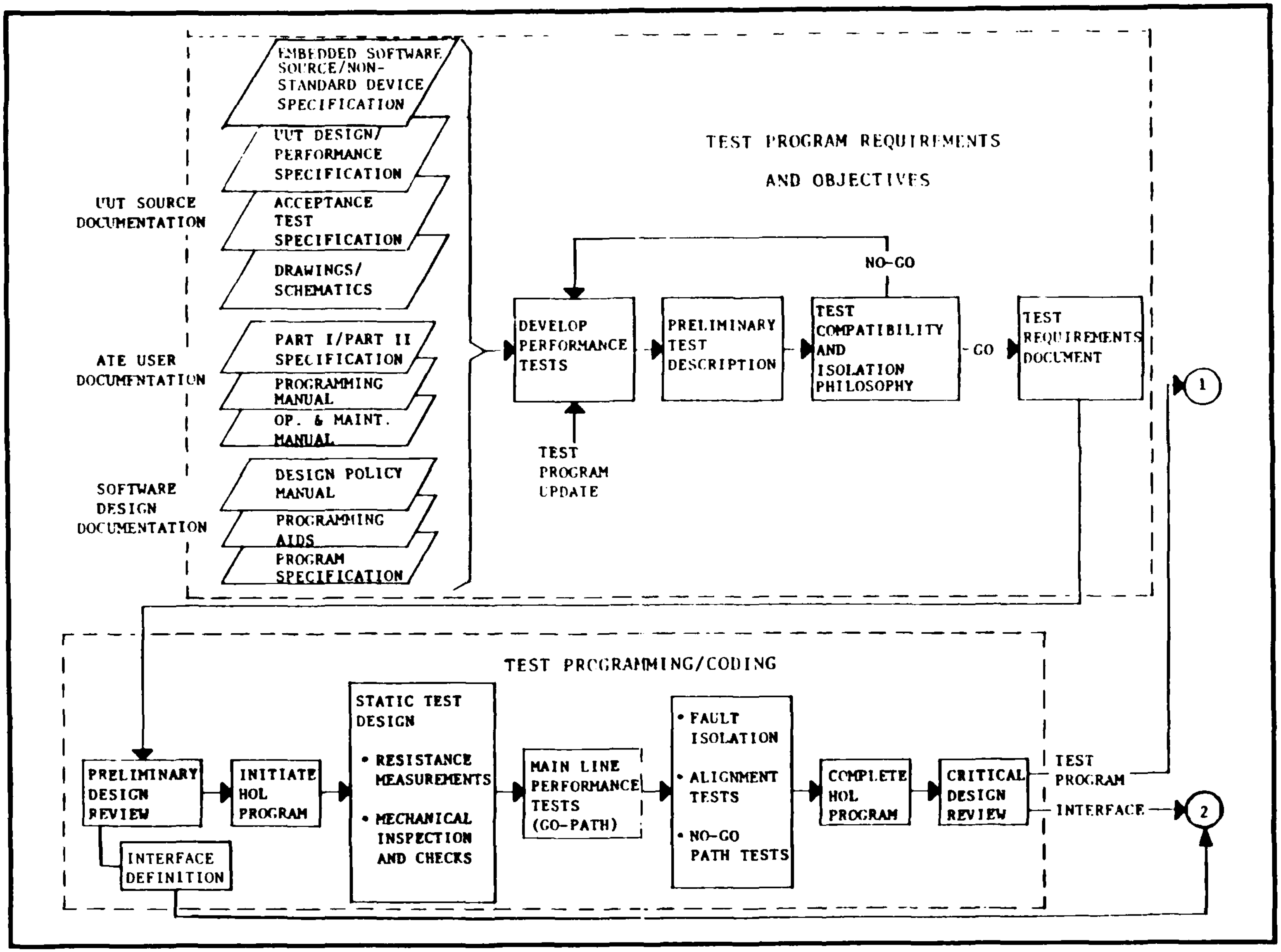


FIGURE 4-1. TPS DEVELOPMENT AND MAINTENANCE PROCESS (AIR FORCE) (CONTINUED)

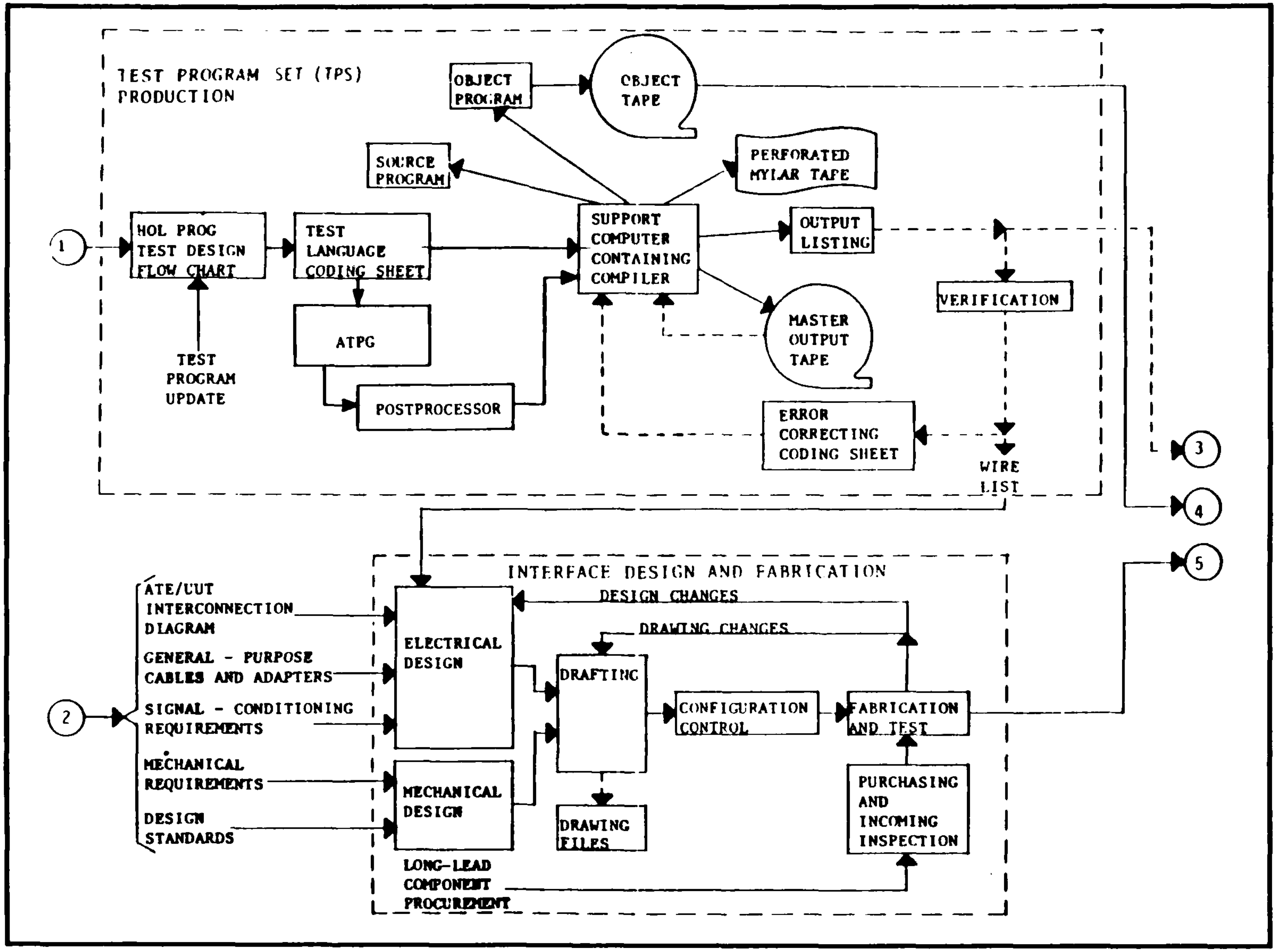
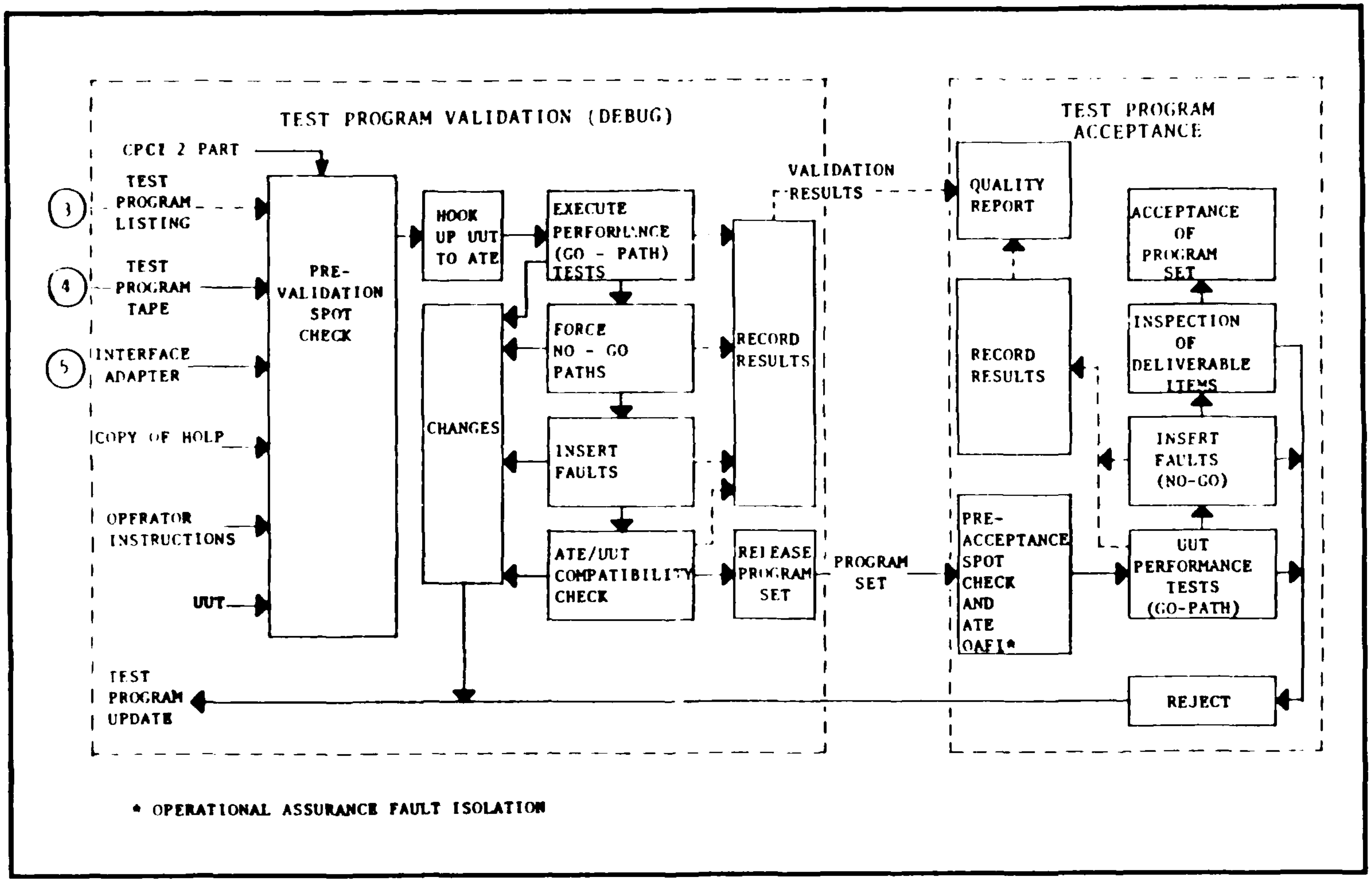


FIGURE 4-1 TPS DEVELOPMENT AND MAINTENANCE PROCESS (AIR FORCE) (CONTINUED)



* OPERATIONAL ASSURANCE FAULT ISOLATION

Tailoring. The preparation instructions in MIL-STD-1519 ensure that the resulting TRD provides a test program source documentation baseline (independent of the ATE on which the TPS is to be implemented) that can be used for the acquisition of a test program and its life cycle support (maintenance). Development of a TRD, however, is a laborious, tedious, time-consuming, and expensive process. Furthermore, UUT configuration changes from preproduction prototypes to production baseline require TRD updates; and program schedules often require starting with TPS development before a complete TRD can be prepared. As a result, most contracts that require delivery of TRDs have been tailored to the specific needs of each program. For example, during full-scale development, TRDs may be limited to functional, end-to-end tests of major assemblies, with subsequent expansion into fault diagnostics at the component level after the program transitions into production. If the prime contractor is also to produce the TPS, the TRD to be delivered may be limited to only those data required for configuration control and TPS verification/validation testing. Alternatively, earlier in the program, limited TRDs may be contracted solely to acquire data necessary for ATE selection or maintenance concept evaluation. For many of the currently fielded TPSs, a complete TRD has never been acquired. The absence of a TRD makes organic maintenance of the associated TPS very difficult although not necessarily impossible as long as UUT technical data are available in other forms.

Verification/Validation. The TRD is supposed to provide a complete specification of all tests required to ascertain that the UUT is operating within design performance parameters, including detailed specifications of UUT input conditions, output measurements, and digital patterns. All three TRD military standards include comprehensive UUT descriptions, drawings, wiring diagrams, and information on theory of operations and operational software. The Navy version also includes ATE information and ATLAS (Abbreviated Test Language for All Systems) statements corresponding to the English language test descriptions. While each of the standards requires contractor delivery of a validation certification to the procuring activity, the specific quality assurance provisions differ. MIL-STD-1519 requires the supplier to apply the inputs and loads specified in the TRD to a certified good UUT and verify that the specified parameter values are obtained – a process to

be witnessed by a procuring activity representative. If the UUT is not available, however, this requirement is, of course, waived. MIL-STD-2076 requires the supplier to deliver a "verified UUT performance characteristic/test requirements matrix," and specifies that the procuring activity "reserves the right to witness any of the inspections/validations specified herein." In summary, the only tools are that DoD has for verifying completeness, accuracy, and validity of a TRD empirical evidence, and even that evidence is often not available in the absence of UUT hardware. Thus, the DoD ultimately must rely on the professional expertise of the contractor in procuring a TRD.

Automated Tools. Contractors have developed various types of automated tools to reduce the amount of tedious, repetitive, manual labor involved in generating a TRD. Most appear to be pure automation approaches, but more sophisticated systems have been designed to consolidate all activities for TPS development into a single "programming environment," including generation of TRDs, ATLAS test procedures, target ATE test programs, test program instructions, and interconnection device design. Only a few developers, however, have recognized the applicability of other engineering tools, such as the Failure Mode and Effects Analysis (FMEA) conducted by design engineers in proving reliability performance and assessing BIT requirements to TRD generation and verification.[8]

Comments. Although the TRD is the preferred format for providing UUT technical data including test requirements, it often is not available when needed. In addition, the TRD reflects factory quality-assurance tolerances, which frequently differ from operational tolerances. If these differences are not recognized in subsequent steps in TPS development, then the fielded TPSs will have a high rate of Type I errors (declaring a component bad when it is actually operational). These and other problems may explain why the Navy and Army are deemphasizing the importance of the TRD. The Air Force, however, continues to stress the importance of the TRD as a necessary, if not

[8]The Rome Air Development Center's current research and development program includes a project entitled "Automated Test Requirement Document Generation," for which recently a contract was awarded with planned completion in mid-1987. It has also sponsored a number of studies of automated FMEA techniques and it is planning to evaluate the use of such techniques for TRD verification.

sufficient, condition for a good TPS. Essentially, the difference between the Air Force and Navy is that the Air Force treats the TRD as a "living" document to be updated as engineering changes are made in the associated UUT. In contrast, the Navy believes this approach is not affordable and not cost effective; it treats the TRD as a "static" document and uses a less-detailed document (described in the next subsection) to keep test requirements data current. The viewpoint of TPS developers is best summarized in the following statement: "TRD misinformation has been proven, time and time again, to be a backbreaker of TPS development."[9]

Test Requirements Analysis

The next step consists of a comprehensive analysis of UUT source data (preferably in the form of a TRD), ATE documentation, TPS design policy (if any), and the subsystem/UUT maintenance concept. The purpose of this analysis is to determine the exact stimulus and measurement criteria to be used in the test program and the ATE/UUT interface impedance-matching and signal-conditioning requirements. The results are documented in a Test Strategy Report (TSR).[10] As indicated earlier, the Army and Navy place more emphasis on the TSR than on the TRD; considerable overlap exists between the two, but the nature of each document is different. The TSR contains the following material:

- UUT functional description
- UUT operating mode description
- Test concept, consisting of a step-by-step breakdown of the stimulus requirements and measurement parameters and accuracies for each functional test in the performance test sequence as well as the general fault-isolation approach

[9]Honeywell Systems Research Center, Unit Under Test Simulator Feasibility Study, AFWAL-TR-80-1091 (Wright-Patterson Air Force Base AFSC/Aeronautical Systems Division/Avionics Laboratory, June 1980).

[10]Content and general format of the TSR are specified in MIL-STD-2077(AS), "Test Program Sets, General Requirements for"; 9 March 1978. This standard is also invoked by the Army's TPS specification with regard to TSR preparation but not by that of the Air Force's. The Air Force does not recognize the term TSR nor the concept of a TSR as a separate deliverable in addition to the TRD.

- Test constraints, consisting of specification of any incompatibilities between UUT and ATE and the resulting interface requirements
- Test summary, consisting of descriptions of the power, sync, and signal inputs required by the UUT and corresponding outputs to be monitored by the ATE
- Operation interaction
- Run time prediction.

The actual or potential problems with the TSR are similar to those listed for the TRD. Specifically, DoD has not developed tools to aid in evaluating the completeness and validity of the tests documented in the TSR; instead, it must rely on the thoroughness of design reviews conducted by, or on behalf of, the procuring activity. Another problem, especially when TPSs are procured competitively or developed under little interaction with the UUT designer, is that the test strategy may be based on factory acceptance test procedures and circuit analyses rather than functional testing in the operational environment. Such a strategy, however, can result in numerous testing problems (Type I errors) and excessive TPS run times.[11] Alternatively, DoD appears in need of a strategy that reflects how the UUT performs in the next higher assembly. The elements of that strategy should include:

- Implementation of the UUT's BIT
- Functional testing in lieu of parametric testing, including simultaneous application of input signals simulating the operational environment and use of test tolerances representative of the UUT mission requirements.

Such a strategy, apparently, has seldom been adopted in the past.

TPS Development

The next steps in TPS acquisition are the design and documentation of the TPS, including test program, test program instruction, and interface device(s). A variety of aids were developed in the 1970's to support TPS development, including automatic test program generators (ATPGs) for digital UUTs. The TPS design is usually documented in the form of functional flowcharts and diagnostic flowcharts. The test sequence normally consists of: (1) identity checks, to

[11]See, for example, J. Luis Hernandez and R. Glenn Wright, "Test Program Runtime in Today's ATE Environment," AUTOTESTCON '83.

verify that the proper UUT and interface device have been connected correctly to the ATE; (2) survey or self-tests, to verify that ATE functions required for executing the test program are operational and to localize any detected ATE faults; (3) safe-to-turn-on tests, to detect any short circuits that might damage the UUT, interface device, or ATE when power is applied to the UUT; (4) static or dynamic performance tests, to check UUT performance under static or dynamic operating conditions in accordance with the TSR; (5) fault-isolation tests, to isolate detected UUT faults to a specified replacement level. Some of the basic problems with test program design are described in the following subsections.

Simplifying Assumptions. It is not uncommon for the developer to make several simplifying assumptions when designing the TPS.[12] These assumptions serve to limit fault detection to single, "hard" failures occurring within electronic components. In addition, failures caused by poor workmanship, basic design deficiencies, incorrect factory assembly, accidental damage, UUT cannibalization, or combat damage are normally excepted from the TPS design logic. As a result, certain failures encountered in the operational environment (i.e., failures in wiring or interconnectors, multiple failures, intermittent failures in digital modules, components damaged by poor handling, or faulty modules as a result of inadequate quality assurance) invariably cause ambiguous fault detection or isolation results. These types of failures, however, may be as frequent as the types of failures which the TPS is designed to detect. For example, in the case of modern digital avionics, studies have indicated that about 50 percent of the failures encountered in operational use do not satisfy the TPS design assumptions.[13]

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[12]See, for example, Program Design Handbook for Automatic Test Equipment, (Washington, D.C.: Naval Air Systems Command, August 1979). This handbook, describing the entire TPS development process, was prepared through the cooperative efforts of RCA, Grumman Aerospace Corporation, PRD Electronics, AAI Corporation, Vought Corporation, and AMG Associates.

[13]OSD-IDA R&M Study Report, "Steps Toward Improving the Materiel Readiness Posture of the Department of Defense," 30 vols., (Alexandria, Virginia: Institute for Defense Analyses, August 1983). Specifically, Volume IV, Technology Steering Group Report, Appendix III, provides data on the percentage of avionics failures attributed to cables and connectors, summarizing the more detailed data reported in Cabling and Connectors Technology, IDA Document D-29 This percentage is estimated to range from 5 to 50 percent depending on age of aircraft, while others claim it may be as high as 60 percent. (This reference actually pertains to BIT software, but similar arguments apply to off-line test programs for LRUs.)

Test Tolerance Limits. Establishing proper test limits for static and dynamic tests is ultimately a compromise between passing defective UUTs (Type II errors) and failing good UUTs (Type I errors). In practice, it is impossible to set test tolerance limits such that both types of errors are eliminated. Three factors must be considered in establishing test limits in TPSs for fault detection as well as fault isolation: (1) upper and lower tolerance bounds on UUT output and circuit test point signals, (2) the "cone of tolerance" concept, and (3) test instrument measurement and stimulus accuracies.

Different techniques are employed for defining upper/lower tolerance bounds on UUT signals under normal operating conditions, including worst-case analysis, statistical circuit analysis, and empirical techniques. While worst-case design analysis is a reliable approach guaranteeing a 100-percent yield during any performance test (i.e., a UUT manufactured in accordance with such a design is virtually guaranteed to pass the performance test), the approach may not be appropriate for in-service testing because defective UUTs can pass the test. A statistical analysis approach (commonly a root-sum-of-squares analysis) is more difficult to perform, but places tighter tolerances on the UUT output signals, resulting in elimination of Type II errors at the expense of slightly lower yield (theoretically, 99.7 percent) and possibility of Type I errors. To achieve/sustain maximum mission capability, weapons system maintenance should minimize the occurrence of Type II errors even at the expense of some affordable level of Type I errors. Where current TPS guidelines suggest worst-case analysis for determining tolerance limits, they should be revised to emphasize the use of statistical analysis whenever feasible.[14]

The second factor, the tolerance cone concept, refers to the vertical relationships among tolerance values at different levels of testing (both maintenance echelon and equipment breakdown

[14]For a numerical example illustrating the benefits of the statistical analysis approach over worst-case analysis, see: Charles Hafer, "Establishing Realistic Test Tolerance Limits for Test Program Sets," AUTOTESTCON '83, pp. 109-117. This advice is in contrast to that offered in the Navy's TPS Design Manual, which recommends the use of worst-case analysis for test limit selection [see: Program Design Handbook for Automatic Test Equipment, (Washington, D.C.: Naval Air Systems Command, August 1979) p. F-4].

structure), with the tightest tolerances at the factory and piece-part levels. Ignoring the tolerance cone in defining tolerance limits invariably causes testing errors. Past experience, for example, shows that this factor has been a major contributor to the "cannot duplicate," "retest okay," and "failed system check" problems encountered in avionics maintenance.

The third factor, test instrument measurement/stimulus accuracy, refers to the closeness of a measurement to its true value as fixed by a universally accepted standard. In the development of TPSs, it is not uncommon to specify an accuracy ratio (defined as the ratio of UUT tolerance to test instrument accuracy) of at least 3:1 or 4:1 for each programmed go/no-go performance test. When this ratio cannot be achieved by available test procedures (e.g., when the standard ATE that must be used lacks the required test accuracy), test limits must be widened from the analytically determined tolerance limits or ATE capabilities must be augmented (either by the ATE itself or by use of an active interface device). One problem is that both accuracy (as defined above) and resolution (defined as the smallest change in a signal attribute being measured that can be unambiguously detected in a measurement process) of test instruments are often degraded in a complex ATE system by the system environment and/or improper calibration procedures and practices.[15]

Failure Priorities. Failure data represent an essential input to TPS development and are normally included in the TRD for the UUT. These data are typically based on the prediction models of MIL-HDBK-217 because virtually all DoD contracts for military electronics require use of this handbook as the source of reliability estimates. Failure mode and failure rate data are needed to determine: (1) the faults to be addressed by the TPS such that the contractual fault-detection rate can be achieved; (2) the most efficient sequence of go/no-go tests in the UUT functional performance (fault

[15]For a brief description of factors influencing test instrument degradation in the ATE system environment, see: Maynard D. Lay "ATS Measurements Today – How Good Are They?" AUTOTESTCON '81, and Robert Buckley, "Commonly Misunderstood ATE Instrument Specifications," AUTOTESTCON '81. For a description of the effects of ATE miscalibration, see the following study pertaining to the Army's EQUATE system: Automatic Test Equipment Calibration/Performance Verification Evaluation and Research Program, NBSIR 82-2601, (Washington, D.C.: U.S. Department of Commerce, December 1982) (For Official Use Only).

detection) test, with items possessing a higher probability of failure placed first in order to minimize TPS execution time; (3) cost-effective tradeoffs between fault isolation resolution and failure frequency, thereby avoiding complex fault isolation logic for failures that seldom occur; and (4) fault isolation thoroughness and diagnostic ambiguity in accordance with contract specifications. As indicated earlier, we believe that the entire process would be improved substantially by a thorough Failure Mode Evaluation Analysis, but this rarely occurs due to the time and cost involved.[16]

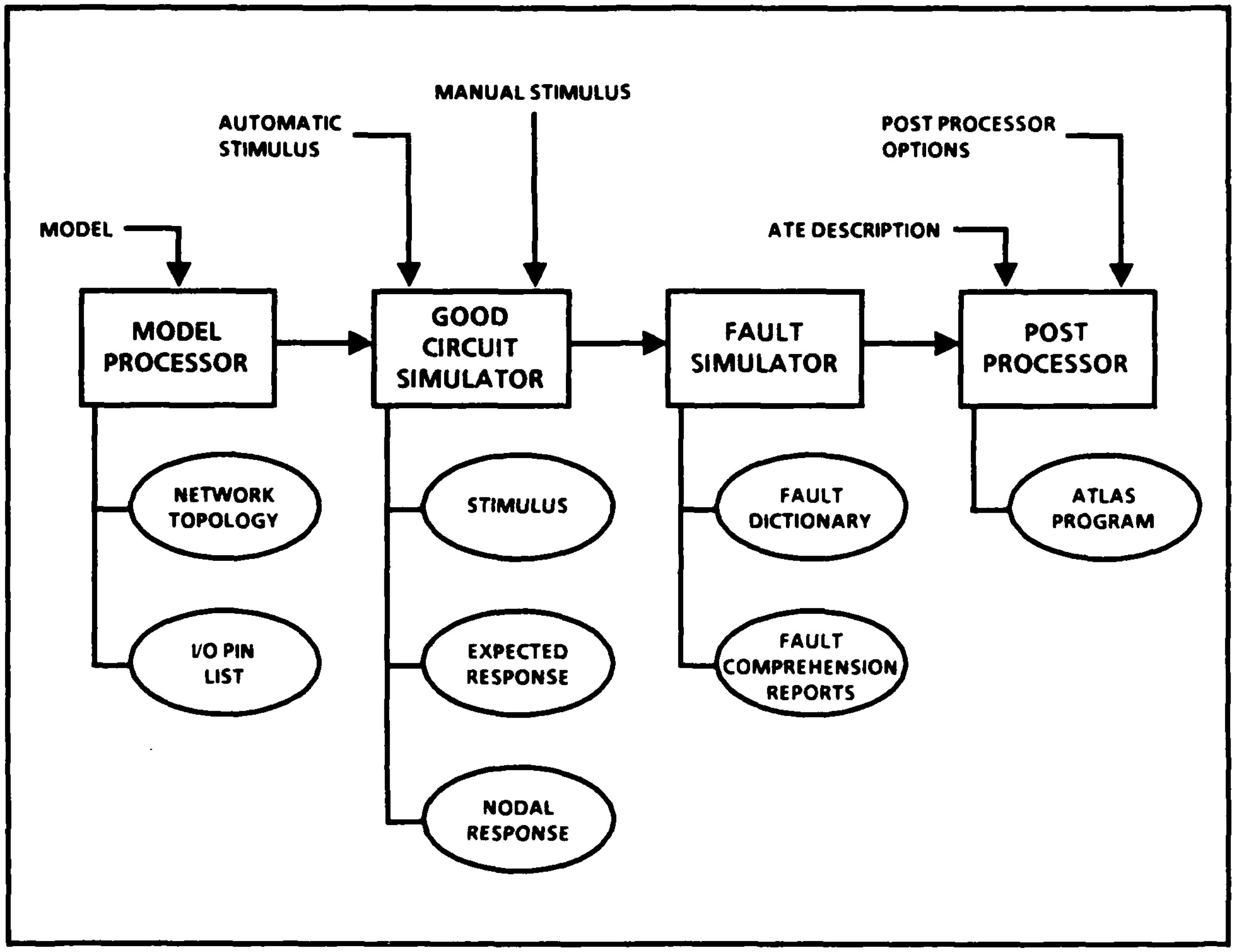
The chief problem with the available failure data for UUTs of a new weapons system is the lack of validity of the engineering estimates. Numerous studies have demonstrated wide discrepancies between predicted reliability and that achieved in the operational environment. For example, the ratio of predicted-to-operational reliability may reach as high as 20:1 for ground as well as airborne electronics. While there is some controversy regarding the implications of this empirical evidence (i.e., the need for either better reliability models or better quality assurance/control of the manufacturing process[17]), the implication for TPSs is clear: failure data feedback from the field environment is essential to improve the run time and diagnostic performance of fielded TPSs because their design assumptions are, by necessity, invalid. In those cases in which this type of feedback has occurred, TPS run times have been reduced by 50 percent or more.

Automatic Test Program Generators. The general structure of an ATPG is illustrated in Figure 4-2 The first phase consists of generating a model of the UUT, based on logic diagram input specifications. The ATPGs that are currently available differ from each other in terms of level of modeling capacity and availability of integrated circuit libraries. Output from this phase includes a

[16]For a brief description of alternative FMEA techniques and the implementation of a Government-owned, standardized, automated FMEA system (completed in 1984), see: Heather B Dussault, "Automated FMEA – Status and Future," 1984 Proceedings Annual Reliability and Maintainability Symposium.

[17]Compare, for example, the following two papers: Kam L. Wong, "Unified Field (Failure) Theory – Demise of the Bathtub Curve," 1981 Proceedings Annual Reliability and Maintainability Symposium, and Clifford M. Ryerson, "The Reliability Bathtub Curve is Vigorously Alive," 1982 Proceedings Annual Reliability and Maintainability Symposium.

FIGURE 4-2. AUTOMATIC TEST PROGRAM GENERATION PROCESS



SOURCE: Terry E. Campbell, "LASAR to ATLAS Post Processing," AUTOTESTCON '83.

topology data base (defining all UUT components and their interconnections) and an input/output pin list for subsequent use by the system.

The second phase consists of an interactive loop comprising stimulus pattern generation (either provided automatically by the system or input by the user in an interactive ATPG process), good circuit simulation, and fault simulation. The good circuit simulation process determines the UUT model responses to the generated stimulus pattern, creating data files on the expected responses at the output pins for each stimulus pattern (the response data in combination with the stimulus data constitute the go/no-go tests) and the model response data (which, in combination with the topology

data base, provide the information for guided probe diagnostic testing). The fault-simulation process determines the UUT model responses to the generated stimulus pattern in the presence of faults, creating a fault dictionary data base, a listing of undetected faults, and metrics of fault coverage achieved. The available ATPGs differ in the methodology of stimulus pattern generation (the most effective and frequently used method is known as "path sensitization,")[18] level of simulation accuracy (number of logic states and timing simulation), and fault-simulation approach (deductive, parallel, or concurrent).

The third and final phase of the ATPG process consists of a postprocessor to transform the ATPG output data, in combination with ATE descriptive data, into a test program tailored to, and in the language of, the target ATE system.

While ATPGs are an important, if not essential, tool for developing test programs for digital UUTs, some common misperceptions exist about their use and effectiveness. First, all ATPGs require a considerable extent of user interaction, especially when the UUT is a higher level assembly. Thus, they do not reduce the skills required for producing effective test programs compared to those required for a completely manual process; their chief benefit is the increase in productivity of test program engineers or programmers. Second, even the best available ATPG is subject to a number of limitations that restrict the diagnostic performance of the resulting TPS. Among these limitations, the following three are worthy of note.

All ATPGs are limited to certain types of faults (primarily, "stuck-at" faults of some also model such fault types as shorts between adjacent pins and selected integrated circuit faults). None, however, simulates pattern-sensitive faults (a failure mode prevalent in tightly packed components and caused by interference between logic values under certain input patterns) nor certain physical fault modes, such as shorts occurring in feedback loops, for which "stuck-at" models are inadequate.[19]

[18]For a concise description of the path sensitization method, see: John Grason and Andrew W. Nagle, "Digital Test Generation and Design for Testability," Proceedings 17th Design Automation Conference, June 1980.

[19]Ibid.

Another shortcoming is that ATPGs do not account for the differential reliability of the nodes of the UUT. They consider all nodes to be equally likely to fail, given a UUT failure. Because this assumption is invalid, the consequence is that the reported fault coverage (fault-detection rate) is invalid; the percent of failures (weighted by failure frequency) actually detected and isolated by the TPS may be much less than expected and advertised.[20]

Yet another shortcoming pertains to those ATPGs that model UUT devices such as integrated circuits at the functional rather than the gate level. Only a handful of the present ATPGs incorporate a gate-level modeling approach. Yet, several investigations have shown the inadequacy of functional-level models in detecting integrated circuit internal faults that affect UUT performance. For example, a comparative evaluation sponsored by the F-16 Program Office showed that TPSs developed by using functional-level ATPGs could detect only 60 percent of integrated circuit internal faults, while those developed with the aid of gate-level ATPGs detected 98 percent.[21] This difference in detection rates caused the F-16 Program Office to prescribe use of the best available gate-level ATPG, known as LASAR (Logic Automated Stimulus and Response), in contracting for F-16 TPSs.[22] (NAVAIR has also mandated use of LASAR in the development of test programs for all NAVAIR ATE applications. Similarly, the Army's TPS specification advocates the use of a particular version of LASAR, known as D-LASAR, whenever possible.) The consequence of using an inadequate ATPG is false confidence in test comprehensiveness, leaving the user with the incorrect assumption that patterns that detect integrated circuit-pin faults will also detect related internal faults and causing costly problems (Type II errors) in field-level maintenance.

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[20]This deficiency can be corrected by combining an FMEA with the ATPG, as described by: Samiha Mourad, "An Optimized ATPG," Proceedings 17th Design Automation Conference, June 1980. This approach, however, is not a known practice in TPS acquisition by the DoD.

[21]Bruce A. Pomeroy, "LASAR: Quality Assurance for Digital Field Testing," AUTOTESTCON '79.

[22]Many versions of LASAR evolved in the 1970's from the original "D-2 LASAR" that was procured by the Navy. The most powerful version currently available is LASAR Version 6 which is proprietary to Teradyne, Inc. This system has been installed at approximately 150 sites within the United States, about 60 percent of which are defense related (defense contractors and military organizations).

The third misperception about ATPG effectiveness is caused by the technology trend in prime equipment toward increased integration. While some of the ATPGs have been useful and effective aids in the past, the technology trend (exemplified by large-scale integration and very-large-scale integration, distributed microprocessors, etc.) makes all current ATPGs obsolete, so that more powerful aids must be developed. NAVAIR has sponsored development of a more flexible ATPG designed to cope with the large- and very-large-scale integration complexity. That system, known as Hierarchical Integrated Test Simulator, became the new standard ATPG for Navy avionics in 1984, with strict configuration control maintained by a software configuration control board and limited distribution of source code to other DoD organizations. The advantages of a Government-owned standard ATPG, however, will not be realized if the Navy is not prepared to invest the necessary resources to support continued development, enhancement, and maintenance of the Hierarchical Integrated Test Simulator.

Software Language. Historically, TPSs have been programmed in many different languages. In the 1970's, industry began to move toward adopting ATLAS as the standard test program language. In 1976, the first industry-wide standard for ATLAS was released and approved by OSD as an interim standard language for ATE.[23] By 1980, ATLAS was close to universal adoption by industry, with test programs typically falling into three categories: standard ATLAS, ATLAS subset (no extensions to standard ATLAS, but excluding some vocabulary, statements, or syntactic options), and adapted ATLAS (modified for a particular test environment and not controlled by the ATLAS standard). To promote further standardization, an international subset was prepared in 1981, approved by the Institute of Electrical and Electronics Engineers, Inc. (IEEE) ATLAS Committee and

[23]For a brief history of ATLAS development, starting with the work by the Airlines Electronic Engineering Committee (the ARINC Committee that originated ATLAS) in 1965, see: IEEE Guide to the Use of ATLAS, IEEE Standard 771-1980 (New York: The Institute of Electrical and Electronic Engineers, Inc., 1980). DoD policy was first promulgated in a 1976 letter by the Assistant Secretary of Defense (Installations and Logistics) directing convergence of the two standard test languages at the time, ATLAS and OPAL (Operational Performance Analysis Language), to be replaced by a single test language as of January 1979, with the Navy designated the lead Military Service in the ATLAS standardization effort.

submitted to the IEEE Standards Board, and approved for publication as IEEE Standard 716, Common ATLAS (C/ATLAS), in early 1982 (with syntax diagrams published separately in IEEE Standard 717). Since 1981, the Military Services have designated C/ATLAS IEEE Standard 716-1982 as the standard test language, so that a standard compiler can now serve multiple applications. Both standards, IEEE Standard 416 and IEEE Standard 716, are reviewed and updated annually under the auspices of the "Standards Coordinating Committee for ATLAS and Related Standards," which is known also as the IEEE ATLAS Committee. That committee also oversees the Users Guide Subcommittee (IEEE Standard 771) and subcommittees charged with developing three new draft standards: test equipment description language, UUT description language, and ATPG output data format.

Most of the fielded TPSs have been written in some form of adapted ATLAS or in other languages, which causes problems when they must be updated because of UUT changes or when they must be transferred to a different ATE because of ATE obsolescence. These problems, however, will gradually disappear as C/ATLAS becomes more widely implemented.

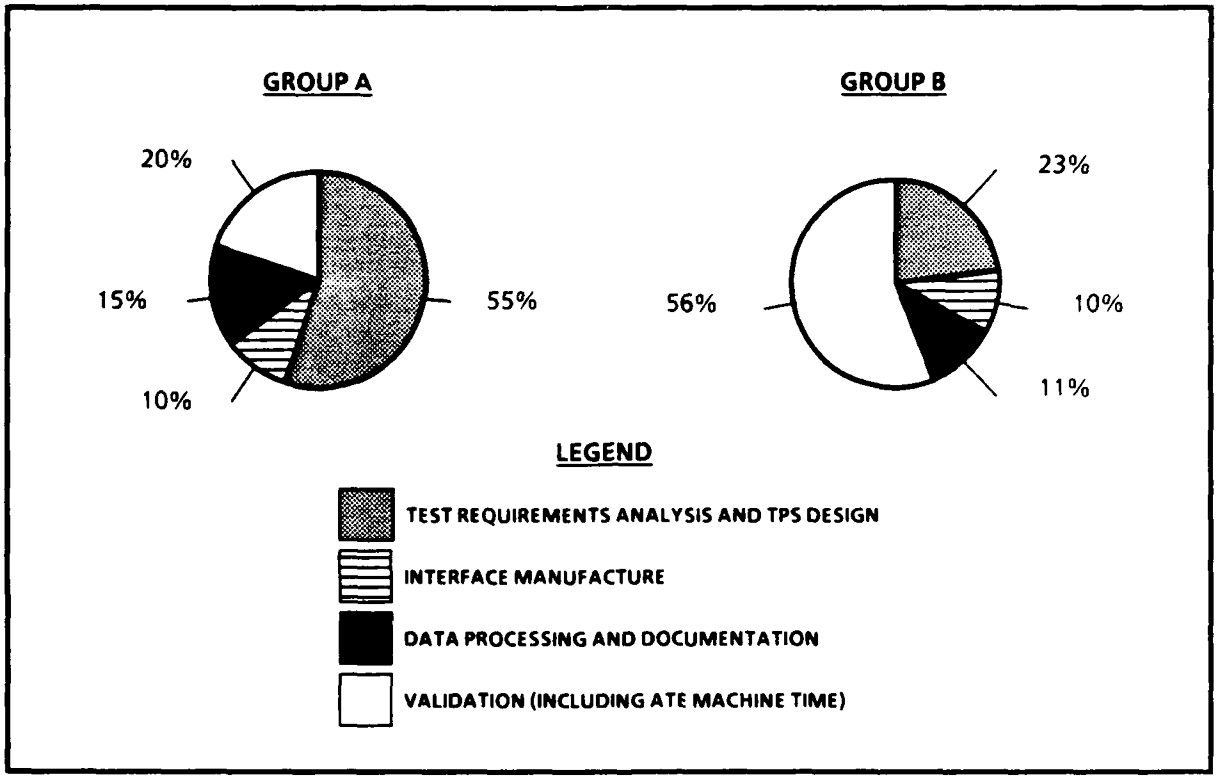
Another problem, which is inherent to any language standardization effort, is that the vocabulary does not meet all testing requirements. ATLAS is thus designed to permit use of non-ATLAS sections in a test program. With further enhancements to ATLAS, the expectation is that the need for such nonstandard extensions can be minimized. Since the first issue of ARINC Specification 416 (October 1968, for analog tests only), ATLAS has already grown from 34 verbs, 30 nouns, and 200 other words to over 500 characters and keywords in level 21 (published in 1984).

TPS Integration and Acceptance Test

The final steps in the TPS acquisition process are known as "integration" and "acceptance test." Integration refers to exercising the TPS on the ATE with the UUT, interface device, cables, and documentation in order to validate and verify TPS performance. This is normally performed in three phases: (1) forcing the TPS through its functional go-path tests, using a known good UUT; (2) forcing no-go paths; and (3) physically inserting failures in the UUT. After the test program has been debugged and integration successfully completed, TPS performance is

demonstrated in a final acceptance test procedure in accordance with a contractor-prepared, Government-approved acceptance test plan. The overall process, i.e., integration and acceptance testing, typically accounts for 25 to 55 percent of the total TPS development cost (see Figure 4-3).

FIGURE 4-3. TPS DEVELOPMENT COST DISTRIBUTION



NOTE: Empirical data based on NAVAIR TPS projects that naturally fall into two distinct groups.

SOURCE: F. Liguori, "Understanding and Controlling ATE Software Costs," Automatic Testing '76 Conference Proceedings, March 1976.

Although TPS integration requires expert skills, many of the major problems in practice are related to the availability of ATE machine time, UUTs, and associated repair parts (to repair a UUT after fault insertion). The ATE machine time required for TPS verification is considerable. One rule of thumb is 1 hour for each test (defined as comprising all test program statements associated with setting up stimuli, routing the signals, executing, and evaluating one measurement

of a UUT parameter). Since many TPSs contain hundreds of those tests for a medium-complexity UUT, ATE availability can thus easily become a bottleneck in TPS development.[24]

A more fundamental problem is that many of the TPS acceptance test procedures in current use have not been validated, thus creating an unwarranted confidence in the quality of TPSs passing the test. This shortcoming may explain the lack of aggressive action by the Military Services in monitoring performance of fielded TPSs. To illustrate, the acceptance test procedure specified in the Navy's MIL-STD-2077 is based on a statistical sampling plan with the following parameters:

- Acceptance quality level (defined as "the maximum percent defective that for purposes of sampling can be considered satisfactory as a process average") of 2.5 percent.
- Limiting quality (defined as "the worst product quality that the customer is willing to accept") of 13 percent.
- Consumer's risk (probability that a bad TPS is accepted) equals the producer's risk (probability that a good TPS is rejected), with the percentage varying from 1 percent to 25 percent as a function of the UUT's reliability.

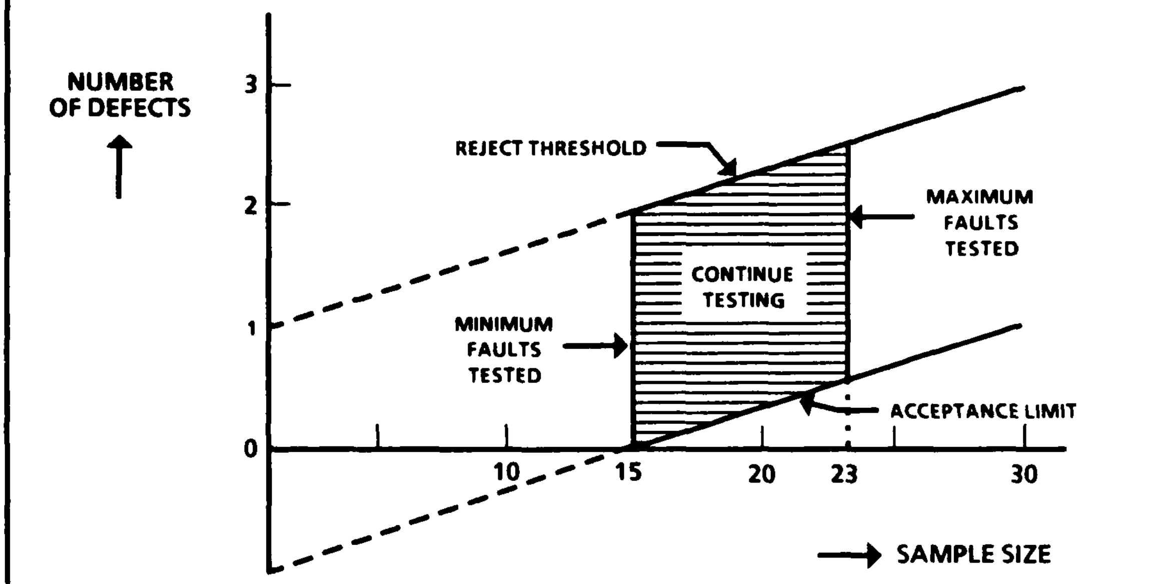
While this sampling plan may be practical for hardware, it is inappropriate for software, where the number of possible test program deficiencies is more a function of UUT complexity, testability, and compatibility with ATE, than of UUT reliability. (Although the statistical laws of quality control stipulate that the level of protection or risk afforded by a sampling plan depends on the absolute, not relative, size of the sample, the notion that a sample should be a certain percentage of the population is a common misperception.) The logic of MIL-STD-2077 leads both to an excessive consumer's risk and a poor quality standard, as the following example illustrates.

For a UUT with a mean time between maintenance actions of 176 to 200 hours, MIL-STD-2077 (Appendix F) specifies a consumer's and producer's risk of 15 percent. The resulting sequential sampling chart is shown in Figure 4-4. The minimum number of faults to be inserted for acceptance testing is 15, given the sampling plan parameters stated in Figure 4-4 and the formulas

[24]Empirical data show that average ATE time for test program validation varies between 0.6 and 1.2 hours per test. For large-scale digital test programs (with thousands of tests), less ATE time is required due to off-line program verification via simulation. Source: F Liguori, "Understanding and Controlling ATE Software Costs," Automatic Testing '76 Conference Proceedings, March 1976.

given in MIL-STD-2077. If the TPS detects and isolates each of these first 15 faults successfully (within agreed ambiguity levels), it passes the acceptance test. If it misses one or two faults, testing continues until a maximum number of 23 fault insertions. If by that time the TPS has missed no more than two faults, it passes the test; otherwise, it is rejected.

FIGURE 4-4. SEQUENTIAL SAMPLING CHART FOR TPS ACCEPTANCE TEST
(Per MIL-STD-2077)



SAMPLING PLAN PARAMETERS

ACCEPTANCE QUALITY LEVEL	=	2.5%
LIMITING QUALITY	=	13.0%
PRODUCER'S RISK = CONSUMER'S RISK	=	15.0%

While this example shows some of the weaknesses in the TPS acceptance test, the weaknesses are actually understated because the inserted failures are selected by the procuring activity from a contractor-prepared fault sample selection list, even though the military standard points out that "the Government reserves the right to select faults not appearing on the fault list provided by the

contractor"). Furthermore, one of the TPS quality metrics, i.e., run time, is never considered in the acceptance test.

The preceding material shows that many of the current practices for testing TPSs have serious weaknesses and that monitoring the performance of fielded TPSs is crucial for quality control. (We do not believe that additional testing will improve TPS performance; high-quality TPS performance can only occur through improved design, not by increased testing.) To illustrate the importance of monitoring TPS performance, every TPS that passes the acceptance test described in the above example may not detect 13 percent of the faults in the UUT, with a 15-percent probability that it may perform worse; its Type I error rate (declaring good UUTs faulty) is unknown because it was not evaluated; its fault isolation resolution for the thousands of possible faults not evaluated in the acceptance test may be much worse than expected; and its run time may be much longer than necessary. Moreover, certain failure modes for digital UUTs, such as dynamic (timing) faults, cannot be inserted or are very difficult to insert; those modes represent, however, a significant portion of the digital module faults encountered in the operational environment.

TPS OPERATION AND SUPPORT

The specific procedures for fielding and supporting TPSs differ among and within the Military Services, but the generic process is the same. Each first production TPS that passes the acceptance test receives a physical configuration audit, after which operational TPSs are produced and distributed to field and/or depot maintenance activities. Audits are performed in accordance with standard procedures.[25] At the time of fielding (Army, Navy) or sometime thereafter (Air Force), management responsibility is transferred from the developer to the cognizant support activity. The latter is normally the same activity that is responsible for life cycle management of the supported UUT. The Army recently centralized TPS management oversight, including establishment of policies and procedures, under the central TPS product manager within the PM, TMDE Office. The Navy has a

[25]See, for example, MIL-STD-1521A (USAF), "Technical Reviews and Audits for Systems, Equipments, and Computer Programs," 1 June 1976 (Notice 2, 21 December 1981)

similar structure but at the Systems Command level (with NAVELEX the lead Systems Command for policy and testing technology). In contrast, the Air Force has dispersed that oversight responsibility among the ALCs (with policies and procedures coordinated through AFLC Headquarters and Air Force Acquisition Logistics Center).

TPS support includes software maintenance (correcting errors or voids in the test program, improving the performance of the test program, or revising the test program as a result of UUT configuration changes or engineering changes or because of ATE changes), technical documentation maintenance, and hardware maintenance (repairing the interface device, fielding engineering changes to improve its reliability or maintainability, or developing changes required to accommodate ATE changes or test program revisions). One practical distinction between UUT and TPS support is that UUTs, once they have been fielded, normally receive at most a few engineering changes during their life cycle, whereas TPS changes are a continuing requirement throughout their life cycle, posing significant management challenges.

Past experience with field-level ATE *has revealed serious problems in the operation and support of ATE*, inhibiting achievement of acceptable or planned levels of productivity. Many of those problems, however, cannot be attributed solely to TPS deficiencies. A 1980 survey of ATE sites rated ATE software (i.e., system software and test programs) near the bottom (sixth out of seven) of problem categories.[26] According to that survey, the five higher ranked problem categories were as follows in order of importance: personnel (inadequate skill level, training, and motivation); operating procedures (lack of automated management information systems); supply (insufficient spares for UUT and ATE repairs); ATE hardware (proliferation of large, single-ported stations, too many and too complex interface devices, operationally unsuitable equipment, and inadequate calibration procedures); and facilities (cramped space and inadequate power and air conditioning). The seventh problem category,

[26]The survey was conducted in the context of the Industry/Joint Services Automatic Test Project that is described in Volume II of this report. A summary of the survey findings is provided in Victor A. Bloom, "The Ultimate ATE Customer – The User," AUTOTESTCON '81

the only one rated as less serious than TPS deficiencies, was publications (manuals arriving too late, out of date, not matching the configuration of the UUT, or poorly organized).

Although the management of TPS support may not be the weakest link in the chain of resources associated with ATE operation and support, we believe there is ample opportunity as well as need for improvements. Four management aspects that are critical to TPS support are logistic support planning and implementation, deficiency reporting and correction, configuration management, and TPS performance monitoring. Those four aspects, as well as the problems in TPS acquisition outlined above, need to be accorded increased management emphasis to effect the potential improvements in productivity proffered by automatic testing and to realize a return that is proportionate to the high investment in ATE and TPSs.

Adequacy of ILS Plan and Implementation

Of all the TPS standards, specifications, manuals, and guides that are in current use, only one mentions the need for an ILS package for the TPS and describes the contracting for, and review of, such a support package to ensure organic supportability of the TPS. That document was prepared by the Navy's Test Technology Information Center (an activity chartered by NAVELEX to acquire, organize, store, and disseminate research, development, test, and evaluation information in the testing area) as a guide for NAVSEA.[27] Not surprisingly, without such guidance, some ILS elements are often ignored in the TPS acquisition process. They include maintenance and supply support for interface devices, support equipment needed to operate the TPS in a calibration mode, telecommunications facilities for test program distribution or modification, and personnel and training. Moreover, as the Navy's guide suggests, TPS support funds need to be separately identified in the overall prime system budget, as well as in the ATE's ILS plan, and TPS acquisition plan, to assure that needed funds are protected. Lack of funding is frequently the excuse for inability to support TPSs when they are fielded.

[27]Test Technology Information Center, Test Program Sets – Life Cycle Costs, Technical Report TM-824-1636 (Corona, California: Fleet Analysis Center, 15 March 1982).

Thoroughness of Deficiency Reporting and Correction

Regardless of how well a test program is checked out during integration and testing, problems will be experienced when the TPS is distributed to maintenance activities and put into operational use. The most common problems include UUT failure modes that are not or incorrectly isolated, false alarms that result from overly tight tolerances or unanticipated noises and transients, and operator errors that are caused by inadequate instructions, misinterpretation, or lack of training. The feedback of information obtained from analyzing such TPS deficiencies is the principal mechanism for improving a test program.

Each of the Military Services has instituted some sort of quality deficiency reporting to capture and correct TPS deficiencies. The level of detail and thoroughness, however, varies considerably. In many cases, the system does not go beyond the standard materiel deficiency reporting procedure; i.e., military operators record materiel deficiencies and forward that data to central collection points on a routine basis for further analysis and corrective action. In others, specifically assigned personnel record all failure events in a detailed way and provide follow-up through systematic fault analysis and error or deficiency correction. This approach often makes use of contractor personnel, while the reporting and correction tasks may be incorporated in the TPS development contract under appropriate warranty provisions for a predetermined warranty period, normally 12 months.

The primary problem with using standard reporting procedures is that they are not very effective in the case of TPSs. In contrast to prime equipment hardware problems, TPS deficiencies are often difficult to pinpoint. Many user sites simply lack the expertise to determine whether TPS problems are due to test program deficiencies or to a host of other potential causes (ATE hardware or software, UUT design, interface device, inadequate operating procedures, environmental factors, etc.). As a result, users are either reluctant to report observed problems with TPSs or they are unable to report anything beyond the fact they are encountering problems. In either situation, TPS managers do not receive the feedback needed to take effective corrective action. The customary practice of the Military Services, therefore, has been to rely on "tiger teams," dispatched to field sites to resolve ATE/TPS-related problems.

Configuration Management

The key document for configuration management of all DoD materiel, including non-data-processing computer programs, is DoD-STD-480A, "Configuration Control – Engineering Changes, Deviations and Waivers," 12 April 1978 (Notice 1, 29 December 1978). It defines configuration management in accordance with DoD Directive 5010.19, "Configuration Management" as:

> A discipline applying technical and administrative direction and surveillance to (a) identify and document the functional and physical characteristics of a configuration item, (b) control changes to those characteristics, and (c) record and report change processing and implementation status.

As it relates to automatic testing, configuration management involves the hardware and software of the ATE, UUT, and TPS. Effective configuration management of each item is critical to the overall maintenance process as well as the performance of TPSs.

Configuration management under the predecessor standard was flawed because it ignored the impact of UUT engineering changes on test programs. For example, engineering changes not affecting form/fit/function were always classified as Class II engineering changes that were not subject to detailed review and documentation efforts. As a result, such configuration changes were often only discovered after the first failure in the field when the TPS did not work. The 1978 revision of the standard, DoD-STD-480A, was designed to correct that deficiency. It implies that engineering changes shall be classified as Class I when maintenance of computer programs or compatibility with support equipment will be affected.

Although the appropriate guidance on configuration management is in place, the Military Services continue to have serious problems with configuration management of TPSs. For example, the Air Force found that 40 percent of the TPSs do not function when they are fielded at the ALCs.[28] Similar Navy-wide data are not available, but the Trident Repair Facility reported in October 1982 that 97 out of 106 TPSs for the AN/UYK-7 computer could not test the circuit boards on

[28]Air Force Logistics Command, A Study of Embedded Computer Systems Support, 9 vols (Wright-Patterson Air Force Base, Ohio: Air Force Logistics Command, September 1980)

hand, and the USS ENTERPRISE reported in February 1983 that 50 percent of the TPSs for the AN/UYK-20 computer could not test the circuit boards on hand. In the Army, the TPSs developed for the Firefinder radars (AN/TPQ-36 and -37) had to be redone after the equipment was fielded because they did not work. In all of these cases, the problem was largely attributed to inadequate configuration management.

Although the Military Services have tightened their configuration management policies and procedures, one significant problem remains—the time delay involved in formal configuration management procedures combined with the frequency or volume of test program software changes. From the time a TPS deficiency is observed and reported, it may take over a year to fix it and field the improved version. Consequently, the Military Services have tried to evolve configuration management procedures that are better tailored to software maintenance. The standard, as revised, recognizes this need by offering the following guidance for computer program configuration items:

> The configuration control over computer program configuration items may introduce a series of documentation terms and change control classification factors which differ from those in DoD-STD-480A. In such cases, the standard should be tailored to clearly define which documents comprise which base line and which factors control the classification of changes. [DoD-STD-480A, Appendix F, p. 73].

In August 1980, the Air Force convened a conference to address problems associated with configuration management of embedded computer software. One of the conclusions coming out of that conference was the following:

> The DoD and subsequently the USAF and its major commands have generated a large number of regulations, directives, and standards that define and direct policies and procedures for accomplishing configuration management. The majority of these policies and procedures for accomplishing configuration management. The majority of these policies and procedures are hardware oriented and have not been tailored for software. Software considerations have been added after the fact . . . The result is that they conflict with each other, use non-standard terminology, and more importantly do not describe a consistent overall policy for configuration management of embedded computer software and its relationship to the hardware elements of a particular system. This lack of consistent policies has resulted in fragmented, unworkable configuration management procedures. Several undesirable situations have resulted. . . . One situation that consistently occurs in the area of ATE embedded computer

> software is the inability of managers to provide corrections and updates to the software user in a timely, efficient manner.[29]

This Air Force conference resulted in identifying a better process for software configuration management. The recommended approach, however, has not yet been included in the pertinent Air Force standard, MIL-STD-483(USAF), "Configuration Management Practices for Systems, Equipment, Munitions, and Computer Programs," 31 December 1970.

The Army's approach to TPS configuration management is based on a configuration management plan established in accordance with MIL-STD-1456 "Contractor Configuration Management Plans." It also performs configuration status accounting in accordance with MIL-STD-482, "Configuration Status Accounting Data Elements and Related Features." It exercises configuration control for test program files following the acceptance test, for TPS documentation following the Functional Configuration Audit, and for test accessories drawings after the Physical Configuration Audit. Engineering changes are processed in accordance with DoD-STD-480A.

The Navy's approach to TPS configuration management, as detailed in MIL-STD-2077(AS), "Test Program Sets, General Requirements for," is also based on formal engineering change control in accordance with DoD-STD-480A.

Both Army and Navy are faced with software configuration management problems similar to those of the Air Force because their procedures are based on the same hardware-oriented standards. In response to those problems, the Navy released MIL-STD-2077A in late 1985 as a Navy, not just NAVAIR, standard. That standard expands the TPS requirements in the areas of engineering support data, documentation, and identification (numbering system). Similarly, the Army released its new Army Test Policy and Procedures Manual in draft form in December 1985. In spite of these efforts, an effective test program configuration management procedure that enables the fielding of software updates in a timely and efficient manner, including the "fencing" of TPS maintenance funds, does not exist, and may require development of a separate DoD standard.

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[29]The 26-28 August 1980 Air Force Acquisition Logistics Division (AFALD) and Air Force Test and Evaluation Center (AFTEC) Embedded Computer System Software Configuration Management Final Report, 21 November 1980.

Monitoring TPS Performance

The extent to which the Military Services monitor the performance (fault coverage, fault resolution, and run time) of fielded TPSs varies substantially. For some weapons systems, a closed-loop feedback system has been installed, as part of the initial TPS fielding effort, to monitor ATE/TPS performance and implement improvements as needed. Those are the exception, however. Normally, those feedback systems are discontinued within a few years after fielding. The primary reason that they are discontinued is cost. For example, the installation and 3-year operating costs of such a system for the F-16 was, reportedly, $60 million.

Apart from such short-term efforts for selected cases, none of the Military Services monitors TPS performance on a permanent basis beyond the data collected through their standard maintenance data systems. Those data, however, consist of worksheets filled out by maintenance personnel and are subject to many limitations. The Air Force decided a few years ago that those data would be inadequate for evaluating TPS and ATE performance. AFLC then developed a management information system for ATE, which was implemented on a pilot basis in 1982. The system requires additional data from the field to augment that collected by the standard maintenance data system. This system, however, has not yet been implemented Air Force-wide.

In contrast to the Air Force, neither the Army nor the Navy has any plans to install a separate system to collect TPS performance data. While NAVAIR has installed a major management information system for retrieving TPS field performance data in various formats, the data being submitted are not of high quality.[30]

The lack of interest by the Military Services in more closely monitoring TPS performance may be closely related to the absence of analytical tools needed to assess TPS quality. For example, when they do not know what the fault coverage, fault resolution, and run time of a TPS should be, the collection of actual TPS performance data is of little use. In the absence of such knowledge, the data by themselves are of little value and certainly not worth the effort of installing a

[30]For a description of this system, see: Ricardo Springs, et al., "Automatic Test Equipment Workload Model for Navy Intermediate Maintenance," AUTOTESTCON '85, pp. 30-36.

separate data collection system. Yet, past experience with TPS improvement projects has demonstrated that the performance of fielded TPSs (especially run time) can be improved substantially through relatively straightforward changes in the test program. Those changes may be as simple as modifying the sequence of tests in accordance with failure frequency. Two examples that illustrate the potential increase in TPS are (1) the Navy's update of TPSs for the S-3A in the late 1970's and (2) the Air Force's update of TPSs for the F-15 electronic warfare subsystem in the early 1980's. In both cases, TPS run times were reduced between 30 to 50 percent at relatively minor cost. Even more drastic improvements, as high as 80 percent, are attainable by using any of the test analysis tools that have become available in recent years.[31]

The message is quite clear. The Military Services need to establish a "should-cost/performance" capability for TPSs, institute feedback systems to accurately monitor TPS performance in the field, and provide the funds required to improve TPS performance. The feedback system does not have to rely on manual reporting by maintenance personnel; it could be a fully automated process using the ATE computer for accumulating a daily log of ATE usage, including identification and test results for each TPS execution, with the daily logs from all ATE sites transmitted to a central processing activity. These actions have the potential to resolve many of the current problems of inadequate TPS performance, thereby improving the return on the DoD's investment in TPSs.

SUMMARY

This chapter has focused on only a few aspects of TPS acquisition and support management and the associated policies, procedures, and practices. Notwithstanding this coverage, it is clear that significant management improvements are called for.

TPS acquisition is as much a black art as it was 10 or 20 years ago. This is best illustrated by the TPS acquisition history for the F/A-18 program. When the prime contractor quoted a bid well beyond budget, the Navy competed the development of most TPSs. The winning bids (for each of three groups of TPSs competed separately) resulted in a contract cost savings of 50 percent

[31]See Dr. K. R. Pattipati, et al., "Time-Efficient Sequences of Tests (TEST)," AUTOTESTCON '85, pp. 49-62.

(approximately $125 million). While the Navy proudly, and justifiably so, points to this case as an illustration of the benefits from competition in TPS development, we believe it demonstrates, as well, the flaws in TPS contract specifications: Anytime the bids submitted by technically well-qualified, reputable firms vary by such a large amount, one conclusion to be drawn is that the statement of work is too ambiguous. One of the primary causes for such ambiguity is that the Military Services have not collected the necessary data on TPS acquisitions and field performance; they also have not developed the analytical tools needed to relate TPS cost and performance to UUT and ATE characteristics.

There is no question that the Military Services are encountering serious problems with TPS performance. Many TPSs simply do not work when they are fielded. When and if they are made to work, fault coverage and fault resolution are frequently well below expectations, and run time is mostly ignored. The primary reason for low TPS quality can be traced to inadequate procedures and tools. Passing the TPS acceptance test is a necessary condition for quality certification, but it is certainly not a sufficient condition. The phased review process instituted by the Navy for TPS development is surely a step in the right direction, but it cannot be fully effective because the Navy cannot verify that the starting document, the TRD, is complete and accurate. Similarly, the application of TPS development tools has focused largely on ATPGs, but there are other test analysis and simulation tools that need to be exploited to optimize TPS performance. TPS development contracts should not merely include performance goals but also hard requirements, with a test improvement warranty concept similar to that used for hardware reliability improvements. Once fielded, TPS quality must be closely monitored through a closed-loop feedback system and improved in all three respects (fault coverage, isolation, and run time) until it meets contractual/planned performance levels. Such monitoring needs to be completely automated, using the ATE computer, instead of relying on manual job sheets. Only after a TPS has been operationally certified as meeting requisite performance levels, should life cycle management be turned over to the user.

TPS support has improved recently because of the lessons learned in the 1970's when the Military Services tried to cut costs by not procuring the technical data (TRDs and supplementary UUT technical data) needed for TPS maintenance. However, some of the support problems caused by

ignoring other ILS elements have received less attention. Additionally, current configuration management procedures are not well suited to cope with the volume and frequency of software changes, nor are current budgeting procedures adequate to provide for ongoing software maintenance funds. Test program maintenance tools, such as engineering work stations with associated data bases, would facilitate TPS maintenance and increase productivity of scarce personnel, but the Military Services so far have not invested in those tools. In short, TPS support continues to rely on crisis management, not on a well-planned life cycle program.

The above assessment of the Military Services' management of the acquisition, quality assurance, and support of TPSs is shared by a number of industry representatives. They believe that their consensus is that current DoD-wide problems with TPSs are serious and, unless changes are made, the problems will become worse with the next generation of high-technology weapons systems. Some of the Military Services question the affordability of correcting current problems. As a result, they have shifted their emphasis toward development of a new approach: integrated diagnostics. The integrated diagnostics concepts may well be the solution, but does not extend to currently fielded weapons systems that may remain in the DoD inventory through the late 1990's.

APPENDIX A

ARMY PROGRAM MANAGER CHARTER FOR TEST EQUIPMENT

This appendix contains the current charter of the Army's program manager for test, measurement, and diagnostic equipment (PM, TMDE). The charter was first established in April 1982, following Secretary of the Army approval of the recommendations of the DATAT (Department of the Army TMDE Action Team) Report and the resulting establishment of a centralized TMDE management structure per Secretary of the Army charter for the "U S Army Executive Agent for TMDE," 27 April 1982.

The current PM, TMDE charter differs slightly from an earlier one in that the PM's "reporting channel" (Section I) has been upgraded to Executive Director for TMDE, and his "direct communication channel" (Section VI B) to Chief of Staff, Army. Furthermore, field offices created by the PM now need to be approved only by the Executive Director for TMDE (Section VII). Thus, both the influence and leverage of the PM, TMDE have increased.

The following pages have been retyped from the original copy received from the Army. We have excluded Annex B, "Interface and Participating Organizations."

PROGRAM MANAGER CHARTER

TEST, MEASUREMENT AND DIAGNOSTIC EQUIPMENT

I. DESIGNATION OF PROGRAM MANAGER

Colonel Douglas H. Barclay is designated Department of the Army (DA) Program Manager (PM) for Test, Measurement and Diagnostic Equipment (TMDE). Colonel Barclay assumed project responsibility on 12 April 1984. The PM reports to the Executive Director for TMDE (EDT), through the Commanding General (CG), U.S. Army Communications-Electronics Command (CECOM).

II. MISSION

The PM is responsible for the management of Army TMDE in accordance with Department of Defense Directive (DoDD) 5000.1, 5000.37, 5000.39, and 5000.40; Army Regulations (AR) 1000-1, 750-43, 750-1, 702-3, 700-129, 700-127, 70-61, 70-17, and 11-18; DARCOM-R 715-2, 700-15, 70-1, and 11-16; and other pertinent regulations for program management of the TMDE Program. The TMDE Program includes the Product Manager, Automatic Test Support Systems (PM, ATSS), who is responsible for centralized life cycle management of the Army's automatic test support systems and equipments; the Product Manager, Army TMDE Modernization (PM, TEMOD), who is responsible for centralized life cycle management of the Army's electronic TMDE Program, future developmental and nondevelopmental items of general-purpose, electronic TMDE, and expansion of the TMDE Modernization Program to all classes of TMDE; and the Army Test, Measurement and Diagnostic (TMD) Technology Laboratory (ATTL), which is responsible for the Army TMDE technology base and the Army Standard ATE programming language.

III. AUTHORITY AND RESPONSIBILITY

A. Authority

The PM has been delegated the full line authority of the Department of the Army TMDE Executive Agent (DATEA), as delegated to the EDT, for the centralized management of the Army's Automatic Test Support System, TMDE Standardization and Modernization Programs, technology base programs and standard Army ATE language.

B. Responsibilities

1. Receive, interpret and implement overall TMDE policy as issued by the EDT. Assure that these policies are implemented within his areas of responsibility and that each new system, beginning with concept formulation, has a TMDE pre-in process review at each major decision point to insure integration of TMDE technology.

2. Compile, develop and submit to the EDT the Army TMDE Five-Year Program Plan (FYPP) in support of the Program Objective Memorandum (POM)/Budget Submission. Insure the program plan addresses the Research, Development, Test, and Evaluation (RDTE) Program, the Army Procurement Appropriations Program and the Force Modernization Program.

3. Develop, prepare, coordinate and defend a consolidated program for research, development and procurement of all Army general-purpose TMDE/ATE. Insure this program is fully deveoped and provided to the EDT for inclusion in the DATEA total Army TMDE fiscal submission.

4. Develop and maintain the Army TMDE technology base and manage associated programs. Serve as the Army's central TMDE research and development activity.

5. Manage the modernization and standardization of the Army general-purpose TMDE/ATE inventory.

6. Develop and implement policy, procedures and standards for development and fielding of Test Program Sets (TPS's) for weapon systems.

7. Assess Army mission and weapon systems' test, measurement, and diagnostic needs within his area of responsibility. Initiate action to satisfy identified needs and submit recommendations to the EDT for those needs outside the PM's areas of responsibility.

8. Manage the development of the Army Standard ATE language and insure life cycle configuration control as outlined in Annex A.

9. Prepare technical guidance for DA and DARCOM PMs and commodity commanders in the design and development of TMDE. Maintain an engineering technology center of excellence for TMDE.

10. Oversee development of general-purpose TMDE/ATE.

11. Coordinate all PM policies and procedures with the EDT and other appropriate agencies.

12. Support the EDT on Army, DoD and industrial panels relating to TMDE.

IV. RESOURCE CONTROL

A. The PM will insure that dollar and manpower requirements to accomplish the above responsibilities are developed and submitted in accordance with established DoD/DA/DARCOM manpower/funding channels and procedures for inclusion in the Program Analysis Resources Review (PARR)/Modernization Resource Information Submission (MRIS) for applicable target program years; and that RDTE, procurement, operation and maintenance and stock fund requirements are compatible at all times with life cycle progression of the programs.

B. Army and other departmental monetary resources approved to accomplish the PM mission will be provided to the PM or participating organizations having prime mission or task responsibility utilizing established DoD/DA/DARCOM funding channels and procedures. The PM will, in turn, provide the necessary funding, direction and guidance in accordance with current regulations, policies and procedures. Organizations receiving resources will be required to furnish such status or progress reports to the PM as are necessary in the execution of his mission.

C. The PM is responsible for reporting through appropriate DARCOM Comptroller channels those Foreign Military Sales (FMS) costs incurred by the Office of the Program Manager. Where the PM tasks commands, agencies, or activities to perform at his request, such taskings will include FMS cost reporting as appropriate. Tasked activities are responsible for accuracy and adequacy of their incurred costs. Supply and financial arrangements between participating foreign governments and the U.S. Army will utilize FMS procedures and be documented through the U.S. Army Security Assistance Center.

V. STANDARDIZATION/INTEROPERABILITY

The PM will:

A. Support the EDT on matters involving Standardization and Interoperability (SI) of TMDE, and assist in assuring that SI actions are accomplished in a timely manner.

B. Analyze the TMDE requirements and developments proposed to support primary systems used jointly by the U.S. and other countries. Identify possibilities for standardizing such TMDE.

C. Explore the technical feasibility of interoperating test software on different automatic test equipment used by the U.S. and other countries.

D. Insure NATO and other countries' SI considerations are adequately addressed and presented at all major program reviews.

VI. COMMUNICATION CHANNELS

A. Direct communication is authorized between all participants involved in implementation of the program to assure timely and effective direction and interchanges of information among participants.

B. The PM has a direct channel of communication to the Chief of Staff, Army and the Secretary of the Army should any of the participating organizations fail to respond to project requirements in any of his assigned management areas.

VII. LOCATION AND SUPPORT

The PM TMDE office is located at HQ, CECOM, Fort Monmouth, New Jersey, with necessary facilities, administrative and technical support being provided by that command. Field offices may be created by the PM as required and approved by the EDT without change of charter. Attendant personnel requirements will be in accordance with applicable procedures. Facilities and administrative support will be provided by the command/activity where established in accordance with separately negotiated host/tenant agreements.

VIII. TERMINATION

A. The TMDE Program is diversified and is not easily measured for termination decisions. Accordingly, each time this charter is revised or updated, each reviewing command, agency, headquarters, etc., will recommend to the next higher authority their stated reasons why continued intensive management techniques should or should not be continued.

B. The PM currently estimates that consideration for termination decision should begin on or about FY 2000.

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ANNEX A

PROGRAM MANAGER CHARTER

TEST, MEASUREMENT AND DIAGNOSTIC EQUIPMENT

A. ASSIGNED ARMY RDTE PROJECTS AND TASKS

The PM is responsible for the following RDTE projects and tasks:

Element Code	DA Project	Title
6.37.48.A	1X263748.AJ28	TMD Technology Development
6.37.48.A	1X263748.AJ29	Automatic Test Support Systems (ATSS)
6.37.48.A	1X263748.D244	ATSS Language Utilization and Standardization
6.47.46.A	1E464746.D536	Simplified Test Equipment - Expandable (STE-X)
6.47.46A	1E464746.D537	Intermediate Forward Test Equipment (IFTE)

B. OTHER PROCUREMENT, ARMY APPROPRIATION

The PM is responsible for overall procurement management, including product improvement; engineering in support of production; Producibility, Engineering and Planning (PEP); and Initial Production Facilities (IPF) as required for the following items listed in the Army Materiel Plan (AMP).

BLIN	305171	TMDE Modernization
BLIN	405154	TMDE Modernization
BLIN	205197	Test Station, Electronic Equip., AN/USM-410
BLIN	305240	Test Station, OQ-290(V)1/MSM 105
BLIN	305241	Equip Repair Facility, ERF

C. OTHER ASSIGNED PROGRAMS AND TASKS

The PM is responsible for:

1. Managing the overall integrated logistic support program for all applications of his assigned projects and tasks.

2. Managing operation and maintenance, stock fund, and military construction funds as applicable and assigned.

3. Reviewing and participating, as necessary, in the development and update of the AMP applicable to the TMDE Program to assure compliance with total Army objectives.

4. Maintaining full logistic support and an adequate materiel readiness evaluation of assigned systems by analysis of supply, maintenance, and unit readiness reports and assuring initiation of corrective action on all known or projected deficiencies by appropriate functional managers and commanders.

5. Coordinating other customer and international logistic procurements including coproduction, in-country production, and the provision of technical assistance, as applicable.

6. Other program tasks or items as assigned.

APPENDIX B

LOGISTIC SUPPORT ANALYSIS PROCESS

This appendix provides excerpts from the Military Standard for Logistic Support Analysis, Military Standard (MIL-STD) -1388-1A issued 11 April 1983.

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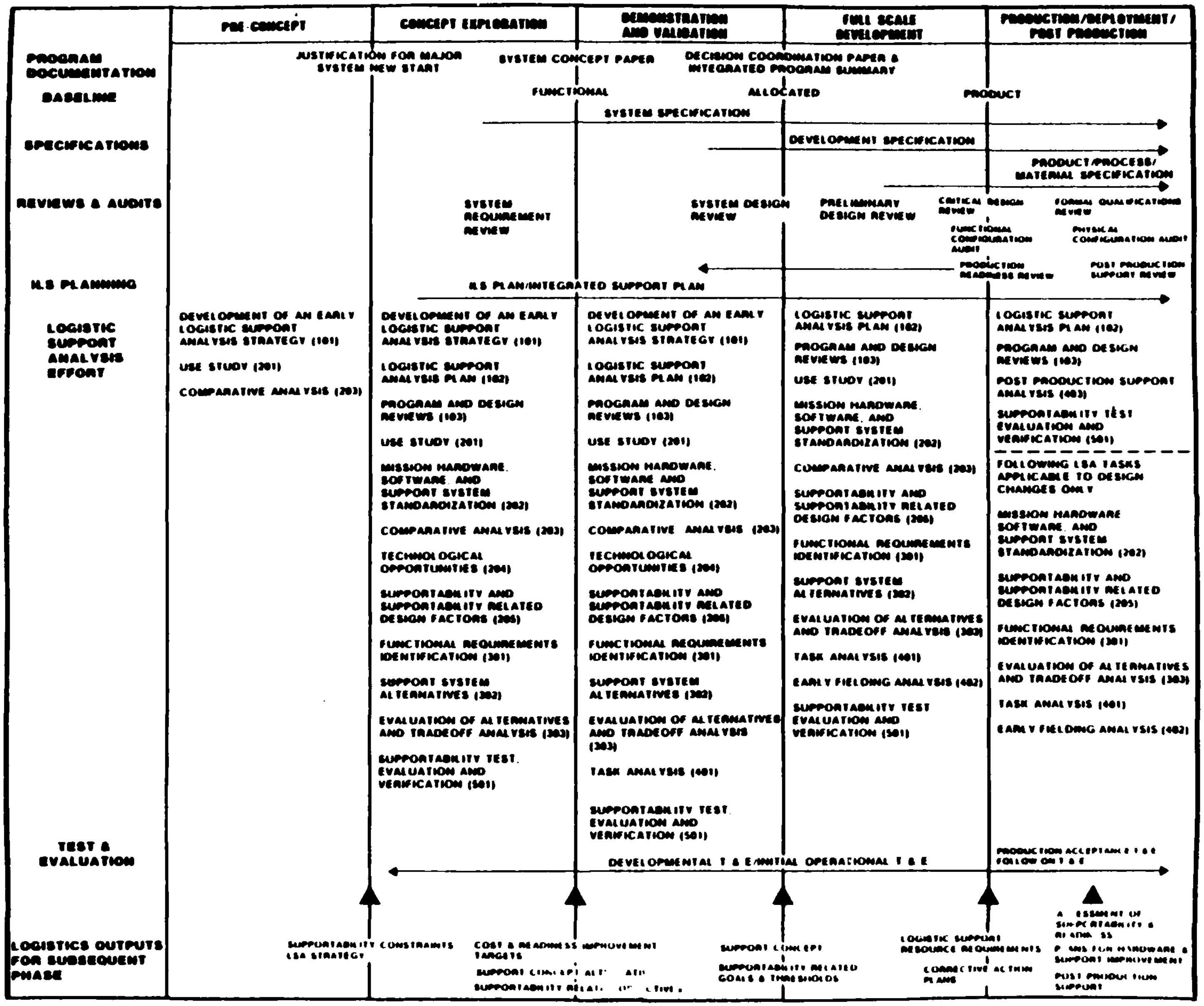

FIGURE 2 Logistic Support Analysis Process Overview

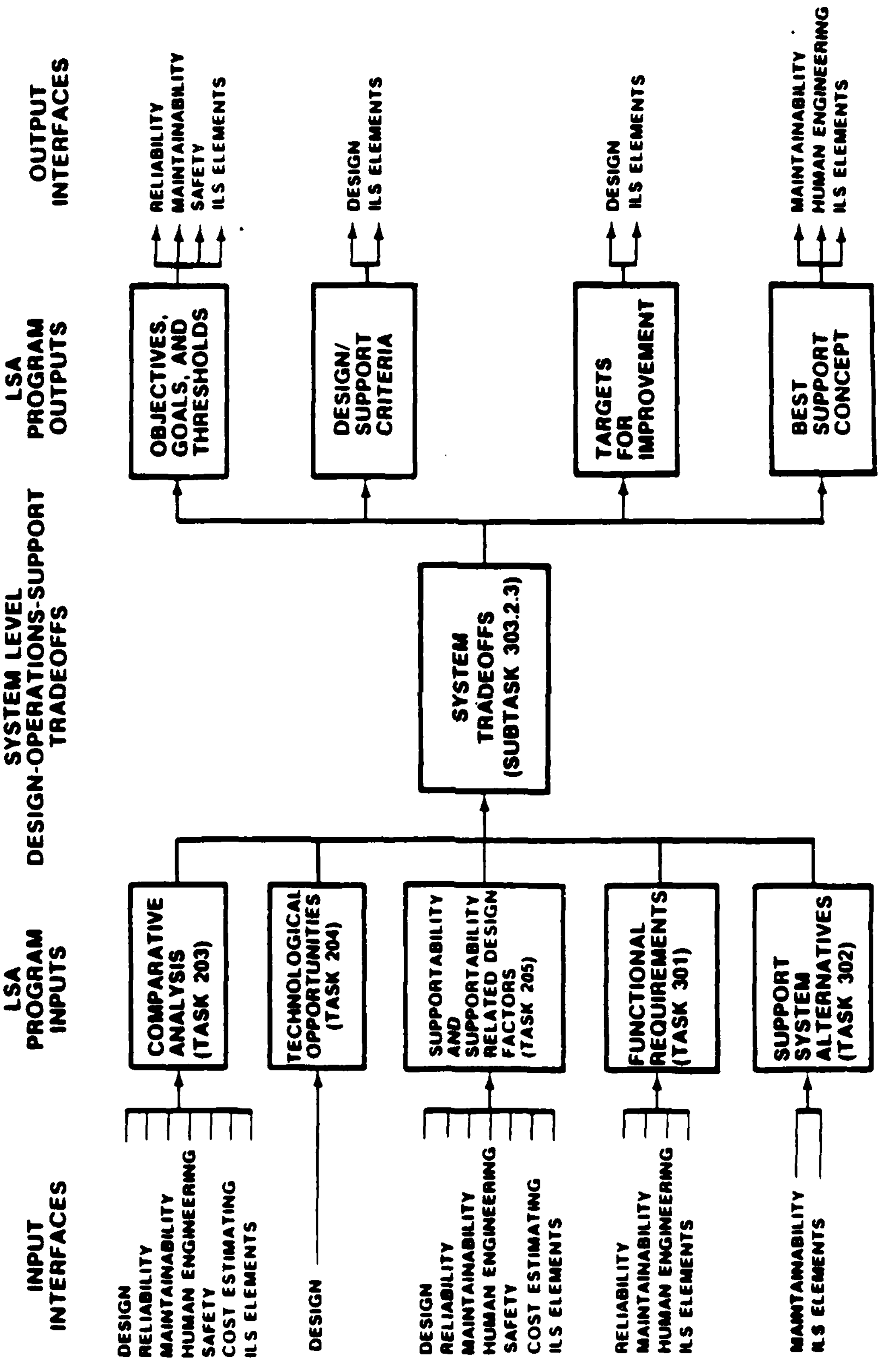

FIGURE 4. System Level Logistic Support Analysis Interfaces.

TABLE I. Index of Logistic Support Analysis Tasks.

TASK SECTION	PURPOSE OF TASK SECTION	TASK/SUBTASK	INFLUENCE * SYS/EQUIP DESIGN	INFLUENCE * SUPPT SYS DESIGN	INFLUENCE * LOG REQMTS DETER-MINATION
100 - PROGRAM PLANNING & CONTROL	TO PROVIDE FOR FORMAL PROGRAM PLANNING AND REVIEW ACTIONS	101 - DEVELOPMENT OF AN EARLY LOGISTIC SUPPORT ANALYSIS STRATEGY	PRIMARY PURPOSE OF 100 SERIES TASKS IS THE MANAGEMENT AND CONTROL OF THE LSA PROGRAM		
		101.2.1 - LSA STRATEGY			
		101.2.2 - UPDATES			
		102 - LOGISTIC SUPPORT ANALYSIS PLAN			
		102.2.1 - LSA PLAN			
		102.2.2 - UPDATES			
		103 - PROGRAM AND DESIGN REVIEWS			
		103.2.1 - ESTABLISH REVIEW PROCEDURES			
		103.2.2 - DESIGN REVIEWS			
		103.2.3 - PROGRAM REVIEWS			
		103.2.4 - LSA REVIEW			
200 - MISSION & SUPPORT SYSTEMS DEFINITION	TO ESTABLISH SUPPORTABILITY OBJECTIVES AND SUPPORTABILITY RELATED DESIGN GOALS, THRESHOLDS, AND CONSTRAINTS THROUGH COMPARISON WITH EXISTING SYSTEMS AND ANALYSES OF SUPPORTABILITY, COST, AND READINESS DRIVERS	201 - USE STUDY			
		201.2.1 - SUPPORTABILITY FACTORS	X	X	
		201.2.2 - QUANTITATIVE FACTORS	X	X	
		201.2.3 - FIELD VISITS	X	X	
		201.2.4 - USE STUDY REPORT AND UPDATES	X	X	
		202 - MISSION HARDWARE, SOFTWARE, AND SUPPORT SYSTEM STANDARDIZATION			
		202.2.1 - SUPPORTABILITY CONSTRAINTS	X	X	X
		202.2.2 - SUPPORTABILITY CHARACTERISTICS	X		
		202.2.3 - RECOMMENDED APPROACHES	X	X	
		202.2.4 - RISKS	X	X	X

* X INDICATES THAT THE SUBTASK IS ORIENTED TOWARD INFLUENCING THE INDICATED FACTOR(S).

TABLE I. Index of Logistic Support Analysis Tasks. - Continued

TASK SECTION	PURPOSE OF TASK SECTION	TASK/SUBTASK	INFLUENCE * SYS/EQUIP DESIGN	SUPPT SYS DESIGN	LOG REQMTS DETER-MINATION
		203 · COMPARATIVE ANALYSIS			
		203.2.1 · IDENTIFY COMPARATIVE SYSTEMS	X	X	
		203.2.2 · BASELINE COMPARISION SYSTEM	X	X	
		203.2.3 · COMPARATIVE SYSTEM CHARACTERISTICS	X	X	
		203.2.4 · QUALITATIVE SUPPORTABILITY PROBLEMS	X	X	
		203.2.5 · SUPPORTABILITY, COST, AND READINESS DRIVERS	X	X	
		203.2.6 · UNIQUE SYSTEM DRIVERS	X	X	
		203.2.7 · UPDATES	X	X	
		203.2.8 · RISKS AND ASSUMPTIONS	X	X	
		204 · TECHNOLOGICAL OPPORTUNITIES			
		204.2.1 · RECOMMENDED DESIGN OBJECTIVES	X	X	
		204.2.2 · UPDATES	X	X	
		204.2.3 · RISKS	X	X	
		205 · SUPPORTABILITY AND SUPPORTABILITY RELATED DESIGN FACTORS			
		205.2.1 · SUPPORTABILITY CHARACTERISTICS		X	
		205.2.2 · SUPPORTABILITY OBJECTIVES & ASSOCIATED RISKS	X	X	
		205.2.3 · SPECIFICATION REQUIREMENTS	X	X	
		205.2.4 · NATO CONSTRAINTS	X	X	
		205.2.5 · SUPPORTABILITY GOALS AND THRESHOLDS	X	X	

TABLE I. Index of Logistic Support Analysis Tasks. - Continued

TASK SECTION	PURPOSE OF TASK SECTION	TASK/SUBTASK	INFLUENCE * SYS/EQUIP DESIGN		
			SYS/EQUIP DESIGN	SUPPT SYS DESIGN	LOG REQMTS DETER-MINATION
300 - PREPARATION AND EVALUATION OF ALTERNATIVES	TO OPTIMIZE THE SUPPORT SYSTEM FOR THE NEW ITEM AND TO DEVELOP A SYSTEM WHICH ACHIEVES THE BEST BALANCE BETWEEN COST, SCHEDULE, PERFORMANCE, AND SUPPORTABILITY	301 - FUNCTIONAL REQUIREMENTS IDENTIFICATION			
		301.2.1 FUNCTIONAL REQUIREMENTS		X	
		301.2.2 UNIQUE FUNCTIONAL REQUIREMENTS		X	
		301.2.3 RISKS		X	
		301.2.4 OPERATIONS AND MAINTENANCE TASKS		X	X
		301.2.5 DESIGN ALTERNATIVES	X		
		301.2.6 UPDATES		X	X
		302 - SUPPORT SYSTEM ALTERNATIVES			
		302.2.1 ALTERNATIVE SUPPORT CONCEPTS		X	
		302.2.2 SUPPORT CONCEPT UPDATES		X	
		302.2.3 ALTERNATIVE SUPPORT PLANS		X	
		302.2.4 SUPPORT PLAN UPDATES		X	
		302.2.5 RISKS		X	
		303 - EVALUATION OF ALTERNATIVES AND TRADEOFF ANALYSIS			
		303.2.1 TRADEOFF CRITERIA	X	X	X
		303.2.2 SUPPORT SYSTEM TRADEOFFS		X	
		303.2.3 SYSTEM TRADEOFFS	X	X	
		303.2.4 READINESS SENSITIVITIES	X	X	
		303.2.5 MANPOWER AND PERSONNEL TRADEOFFS	X	X	X
		303.2.6 TRAINING TRADEOFFS	X	X	X
		303.2.7 REPAIR LEVEL ANALYSES		X	X
		303.2.8 DIAGNOSTIC TRADEOFFS	X	X	
		303.2.9 COMPARATIVE EVALUATIONS		X	
		303.2.10 ENERGY TRADEOFFS	X	X	X
		303.2.11 SURVIVABILITY TRADEOFFS	X	X	
		303.2.12 TRANSPORTABILITY TRADEOFFS	X	X	

TABLE I. Index of Logistic Support Analysis Tasks. - Continued

TASK SECTION	PURPOSE OF TASK SECTION	TASK/SUBTASK	INFLUENCE *		
			SYS/EQUIP DESIGN	SUPPT SYS DESIGN	LOG REQMTS DETER-MINATION
400 - DETERMINATION OF LOGISTIC SUPPORT RESOURCE REQUIREMENTS	TO IDENTIFY THE LOGISTIC SUPPORT RESOURCE REQUIREMENTS OF THE NEW SYSTEM IN ITS OPERATIONAL ENVIRONMENT(S) AND TO DEVELOP PLANS FOR POST PRODUCTION SUPPORT	401 - TASK ANALYSIS			
		401 2 1 TASK ANALYSIS			X
		401 2 2 ANALYSIS DOCUMENTATION			X
		401 2 3 NEW/CRITICAL SUPPORT RESOURCES			X
		401 2 4 TRAINING REQUIREMENTS AND RECOMMENDATIONS			X
		401 2 5 DESIGN IMPROVEMENTS	X	X	
		401 2 6 MANAGEMENT PLANS			X
		401 2 7 TRANSPORTABILITY ANALYSIS	X	X	
		401 2 8 PROVISIONING REQUIREMENTS			X
		401 2 9 VALIDATION	X	X	X
		401.2 10 ILS OUTPUT PRODUCTS			X
		401 2 11 LSAR UPDATES	X	X	X
		402 - EARLY FIELDING ANALYSIS			
		402 2 1 NEW SYSTEM IMPACT			X
		402 2 2 SOURCES OF MANPOWER AND PERSONNEL SKILLS			X
		402 2 3 IMPACT OF RESOURCE SHORTFALLS			X
		402 2 4 COMBAT RESOURCE REQUIREMENTS			X
		402 2 5 PLANS FOR PROBLEM RESOLUTION			X
		403 - POST PRODUCTION SUPPORT ANALYSIS			
		403 2 POST PRODUCTION SUPPORT PLAN		X	X
500 - SUPPORTABILITY ASSESSMENT	TO ASSURE THAT SPECIFIED REQUIREMENTS ARE ACHIEVED AND DEFICIENCIES CORRECTED	501 - SUPPORTABILITY TEST, EVALUATION, AND VERIFICATION			
		501 2 1 TEST AND EVALUATION STRATEGY	X	X	X
		501 2 2 OBJECTIVES AND CRITERIA	X	X	X
		501 2 3 UPDATES AND CORRECTIVE ACTIONS	X	X	X
		501 2 4 SUPPORTABILITY ASSESSMENT PLAN (POST DEPLOYMENT)	X	X	X
		501 2 5 SUPPORTABILITY ASSESSMENT (POST DEPLOYMENT)	X	X	X

APPENDIX C

THE STANDARD INTEGRATED SUPPORT MANAGEMENT SYSTEM (SISMS)

This appendix provides excerpts from the Joint Service regulation on acquisition management, "Standard Integrated Support Management System," including Change 4, 17 September 1982. The excerpts include the Table of Contents, Chapter 1, "Introduction and Concept," and Chapter 5, "Support Equipment."

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HEADQUARTERS AIR FORCE LOGISTICS COMMAND — AFLCR/AFSCR 800-24
Wright-Patterson Air Force Base OH 45433

HEADQUARTERS AIR FORCE SYSTEMS COMMAND
Andrews Air Force Base DC 20334

U.S. ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND — DARCOM-R 700-97
Alexandria VA 22333

NAVAL MATERIAL COMMAND — NAVMATINST 4000.38A
Washington DC 20368

HEADQUARTERS, UNITED STATES MARINE CORPS — MCO P4110.1A
Washington DC 20380 — 27 May 1977

Acquisition Management

STANDARD INTEGRATED SUPPORT MANAGEMENT SYSTEM

This document established the Standard Integrated Support Management System (SISMS) as a management approach jointly agreed to and implemented by DARCOM/NMC/AFLC/AFSC. It provides information on the interrelationships and responsibilities among the executive service, the participating service, and the contractor for multi-service programs; states the agreements which assign responsibility, and describes the policies and procedures that affect organization and preparation for implementation SISMS; contains standardized contract items for the logistics disciplines and provides for the use of standard data item descriptions. The Office of Management and Budget (OMB) approved the SISMS reporting and recordkeeping requirements upon contractors under the authority of OMB No. 0704-0068 expires 31 December 1984.

NOTE: DODDs and DODIs (referenced here) are not available through normal distribution channels.

*Supersedes AFLC/AFSCR 800-24; AMCR 700-97; NAVMATINST 4000.38; MCO P4110.1A, 3 March 1975
OPR: AFLC/LOM; AFSC/LGY
DISTRIBUTION: F; X (see signature page)
USMC PCN: 102 043100 00

Chapter 1

INTRODUCTION AND CONCEPT

1-1. Scope. SISMS must be considered for application to all system/equipment acquisitions (paragraph 1-5). The policies, procedures, and contract requirements are implemented by assimilating or adapting them to the logistics support planning and management routine of each of the commands. SISMS is useful for individual system and equipment acquisition and should be applied consistent with valid requirements of individual system and equipment acquisition and should be applied consistent with valid requirements of individual programs. This approach makes it available for use in all acquisitions in consonance with those Service requirements not covered by SISMS.

1-2. Background. SISMS was conceived to provide a common approach to planning and managing the logistics support of multi-service systems/programs. SISMS was developed under the auspices of the Joint Logistics Commanders (JLC) (US Army Materiel Development and Readiness Command (DARCOM), Naval Material Command (NMC), Air Force Logistics Command (AFLC), and Air Force Systems Command (AFSC)) during the 1967-69 timeframe, initially for multi-service aeronautical systems only. It later became apparent that portions of SISMS could be used on other types of systems/equipments, whether single- or multi-service. In 1970, the JLC agreed to expand the applicability of SISMS and implement its concept as a management principal. The Logistics System Policy Committee (LSPC), chaired by OASD (I&L), recognized the potential advantages of SISMS, and in 1972, SISMS became part of it's long-range plans for improving the overall Department of Defense (DOD) logistics system (DOD Logistic Systems Plan "LOGPLAN" 1972-1980, 15 May 1972). It emphasized the need for the Services to apply SISMS to all system/equipment acquisitions and for the JLC to update the SISMS documentation with the requirement established by the JLC, and the impetus provided by the LSPC, the SISMS documentation was expanded to facilitate broader application to both single- and multi-service systems/equipments.

1-3. Description/Concept:

a. SISMS is an agreement among DARCOM, NMC, AFLC and AFSC to use a uniform approach to logistics planning and management. Joint Operating Agreements (JOA) form the basis of that agreement in those logistics disciplines needed to provide a total logistics support package. The JOAs describe the relationships and assign responsibilities for planning and managing logistics support for all multi-service system/equipments programs. Contract exhibits, related military standards (MIL-STD), and data item descriptions (DID) which describe contractor responsibilities in a program are included or referenced as appropriate for each of the identified logistics disciplines.

b. Two concepts are the foundation for the SISMS documentation:

(1) Integrated weapon support management (IWSM): Clear assignment of authority and responsibility for uniform planning, management, and acquisition of the logistics support program for multi-service systems and equipments.

(2) Integrated logistics support (ILS). Orderly consideration and interrelationships of the logistics support disciplines within the system/equipment requirements.

c. SISMS builds on this basic IWSM/ILS foundation by developing each of its logistics disciplines for uniform application in a multi-service environment. In so doing, it stresses commonality of broad principles and procedures, but permits flexible employment of techniques to allow for individual service or program peculiarities. SISMS recognizes the authority of the executive service throughout design, acquisition, and support, but is sensitive to the requirements of the participating service(s).

d. A JLC Memorandum of Agreement provides the overall management principles for conducting multiservice programs (AFSCR/AFLCR 800-2/AMCR 70-59/NAVMATINST 5000.10A). That agreement assigns responsibilities to the executive service, the participating services, the program/project manager (P/PM), and the participating service senior representatives(s). For program/project-managed programs, SISMS is intended to complement this JLC agreement. It provides the P/PM with established guidelines, organizational relationships, and documentation for the logistics portion of the program. SISMS also applies to acquisitions that are not program/project managed. In these cases, the executive service will assume the responsibilities assigned throughout this regulation to the P/PM.

e. The achievement of a common or uniform approach to the individual disciplines of ILS permits the user to select from and tailor the SISMS to fit the program's peculiar requirements. This flexibility is what makes SISMS meaningful for application in a single-service environment. Its expansion to permit application to single-service system/equipments eliminates the need of considering multi-service programs as anything other than slightly unusual examples of single-service systems. Further, it minimizes the need for the services to maintain two separate approaches to ILS management with their inherent impacts on organization, documentation, and management systems.

f. SISMS consitutes a uniform set of policies and operational methodologies in the ILS process for both multi- and single-service system/equipment acquisitions. For those single-service acquisitions which later become multi-service programs, SISMS would facilitate the transition to multi-service use. Where standardization of procedures isn't possible due to peculiar requirements based on differences in service roles and missions, SISMS provides the methods for handling the interfaces between the Government and industry and among the DOD components.

g. SISMS presents no new or radically different logistics support procedures. The most suitable methods used by one or more of the joint logistics commands have been adapted and adopted in SISMS policies and procedures.

1-4. Objective. Throughout the development, implementation, and revision expansion of SISMS, the basic objectives have remained consistent and valid. Those objectives are to:

a. Provide a single source of information with which the JLC may control and manage ILS programs.

b. Delineate the authority for, and the responsibilities and relationships between, the executive and participating services engaged in a multi-service program.

c. Permit the services/commands to present a "single face to industry" through the application of common concepts, procedures, and policies.

d. Enhance support responsiveness through judicious planning and management.

e. Reduce the costs incurred by duplication in and among the services through the use of common logistics procedures.

f. Integrate and standardize acquisition and logistics support disciplines inot properly time-phased actions to ensure weapon system and equipment readiness.

1-5. Policy. The SISMS is mandatory on multiservice system/equipments; *it is mandatory for consideration on all other systems/ equipments and must be used where advantageous.* Its use or nonuse must be documented according to the JLC's internal procedures.

1-6. Implementation/Application:

a. Three principal interfaces are addressed in SISMS:

(1) Executive/participating services on multi-service programs.

(2) Executive service/contractor on both multi- and single-service programs.

(3) Participating service/contractor on multi-service programs. SISMS has been designed to enhance the flow of data and information at those interfaces through the adoption of standardized policy and the application of standardized procedures, standard contract items, terms, conditions, and data deliverables. The contract requirements, DIDs, various parts of the SISMS document, and references are intended to be assimilated into the general and detailed contractual specifications.

b. SISMS does not cover the complete spectrum of acquisition inputs. There will be occasions when the functional and managerial elements of each participating service will operate under the policies, data, standards, etc. of the executive service according to AFSCR/AFLCR 800-2/AMCR 70-59/ NAVMATINST 5000.10.

c.SISMS is intended to be applied by the use of its standardized contract requirements and related DIDs. The contract requirements tell the contractor what to do; the related DIDS tell the contract what data are to be delivered.

d. The principal documents incorporated in SISMS by reference, which individually address all or part of the acquisition logistic management process are listed in attachment 2. The list is supplemented by the additional references of those parts of SISMS which address specific logistics disciplines.

1-7. Summary:

a. *The mechanism through which SISMS operates the ILS* system is an extension of the existing policies and practices of DOD Directive 4100.35. Of primary importance in this area are SISMS chapters 2 and 3:

(1) Chapter 2. Integrated Logistics Support Management, identifies the organizational relationships for managing logistics programs and references the additional sources of guidance and governing documentation. It addresses the significant contents of the integrated support plan (ISP). It identifies the goals, policy, responsibilities, and interrelationships for conducting the tasks and references the related DIDs, where applicable.

(2) Chapter 3, Logistics Support Analysis Policy and Guidance, addresses the logistic support analysis (LSA) (MIL-STD-1388) as an analytical technique used by the logistics manager to provide a continual dialogue between the designer and the logistician. The LSA identifies the impacts of support alternatives upon design engineering and provides the primary *vehicles for interfacing the related disciplines of SISMS.*

b. Chapters 4 through 9 discuss the logistics disciplines important in the support of systems/equipments. They include the provisioning policies and procedures for spares and repair parts; the equipment, both support and government-furnished; and inventory management procedures. They also include procedures for planning for the facilities to support the system/ equipment and for any transportation packaging and materials handling requirements:

(1) Chapter 4, Provisioning Policy and Procedures, describes the responsibilities for the provisioning of initial repair parts. Standard DOD provisioning policies and procedures are specified by reference. The chapter applies to repair parts for the specified system, and also to support equipment (SE), contractor-furnished equipment (CFE), and training equipment.

(2) Chapter 5, Support Equipment (SE), describes the procedures, terms, and conditions governing the identification, design, and acquisition of end items of SE throughout the system/equipment life cycle. Responsibilities for managing the acquisition of SE are specified. Contract requirements and related DIDS supplement the policies and procedures.

(3) Chapter 6, Government Furnished Equipment (GFE), has the policies, procedures, and responsibilities for managing and processing GFE. Standard GFE milestones are included along with a procedural flow chart. Applicable DIDs cover the delivery schedule of GFE, delivery status, and rejection failure data.

(4) Chapter 7, Inventory Management Procedures. Policies and procedures are included by reference to the appropriate DOD documents.

(5) Chapter 8, Packaging/Handling Storage/Transportability/Transportation, addresses the policy and procedures for transportation, packaging, transportability, and related materials handling requirements during all phases of the

system/equipment life cycle. Contract requirements and standard DIDS supplement the policy and procedures.

(6) Chapter 9. Facilities Determination and Planning. The funding of facilities is normally outside the main system funding process, but the provision of facilities has high cost potential, and this chapter pro-

vides a standardized approach to identifying, defining, and planning for facility requirements. Contract requirements and related data item descriptions are provided.

c. SISMS recognizes the maintenance capabilities of the services at all echelons, the dynamic nature of system equipment repair requirements, and the flexibility that management must have to meet those requirements. Chapters 10, 11, and 12 address three areas which are important adjuncts to the maintenance process: Preoperational support, contractor engineering and technical services, and interservice depot maintenance. They provide flexibility to the logistics manager in arriving at more effective ways to maintain and increase system equipment readiness.

(1) Chapter 10, Preoperational Support, provides the services and the contractor with the policy and instructions for fulfilling system support requirements prior to the system entering the operational phase of the life cycle. This includes preparation of recommended repair parts list (RRPL), SE requirements, and a support material list (SML).

(2) Chapter 11, Contractor Engineering and Technical Services (CETS), will be obtained through the application of standard policies and procedures described therein. The objectives, limitations, and procurement policies are discussed, and included in a description of recommended Standard Certificate of Service. A contract item and a data item description (DID) for a comprehensive CETS plan are also part of this chapter.

(3) Chapter 12, Interservice Depot Maintenance, provides for an organizational structure in each of the services with the mission of enhancing the use of depot resources through increased service cooperation. Three levels of organizations are described:

(a) Maintenance interservice support management offices.

(b) Maintenance interservice support planning group.

(c) Maintenance interservice support offices. Policies, procedures, and responsibilities for the establishment and operation of these organizations provide for the best utilization of the depot maintenance capabilities of the services. A standardized Depot Maintenance Interservice Support Agreement (DMISA) is included.

d. Chapter 13, The Training Program, outlines the responsibilities for development, documentation, and acquisition of the total training program by the executive service including the support responsibilities of the participating service. It addresses the essential phases in the development of a training program. Contract items and related data item descriptions support each phase of the system training program.

e. Chapter 14, Configuration Management, provides for the creation of multi-service configuration control boards (CCBs) for jointly used systems/equipments. A standard outline for a Configuration Management Joint Operating Procedure (JOP) covers multi-service programs. Standard DOD policies and procedures are included by reference to the appropriate documents.

f. Chapters 15 through 19 provide comprehensive guidance for acquisition and management of the various data required in support of system/equipment programs.

(1) Chapter 15, Data Acquisition Management, discusses responsibilities for the management and control of data acquisition for multi-service programs.

(2) Chapter 16, Technical Manuals Acquisition Management, provides the policy and procedures for implementation of a technical manual program. It covers responsibilities for identification of the overall technical manual requirements, preparation of a Technical Manual Plan (TMP), and determination of quality assurance provisions by in-process review, validation, and verification. Contract items and data item descriptions have been provided to integrate the system contractor into this effort.

(3) Chapter 17, Engineering Drawings, discusses current DOD policies and specifies application of standardized data item descriptions for acquisition of engineering drawings and associated lists.

(4) Chapter 18, Data Exchange for Product Improvement, provides for the exchange of maintenance and operational data on all multi-service programs to enhance the decision making process.

(5) Chapter 19, Data Element Dictionary, Provides standard data element definitions by reference to MIL-STD-1388-2.

g. The following chapters provide the policies and procedures for those disciplines which support or sustain the other disciplines. The focus is oriented to standardization of the interfaces between services rather than uniformity of approach within the services.

(1) Chapter 20, Budget and Funding, provides the necessary guidance and references to standard procedures for the transfer of funds for services performed.

(2) Chapter 21, Procurement, provides for joint operation to ensure appropriate delineation of responsibilities between the executive and participating services consistent with Armed Services Procurement Regulation (ASPR).

(3) Chapter 22, Engineering Responsibility, recognizes overall system engineering as the responsibility of the executive service. Additionally, it affords the participating service(s) an adequate participating role along with the direct engineering responsibility for those portions of the systems that are peculiar to the participating service(s).

1-8. SISMS Master Flow Chart (attachment 3). The SISMS master flow chart depicts the typical events and report products of the SISMS activities and relates them pictorially to the system management process. The chart shows how specific data items flow into typical events leading to major decision points in each of the logistics disciplines.

1-9. Procedures For Changing and Requisitioning SISMS. AFLC will be administratively responsible for preparation of all revisions to this document. It is intended that SISMS be kept dynamic. Changes dictated by need for improvement or deficiencies identified during implementation and application should be documented and forwarded to the office of primary responsibility (OPR) as follows:

a. *DARCOM* — Director for Plans, Doctrine and Systems (DRCPS).

b. *NMC* — Deputy Chief Naval Material, Logistic Support (MAT 04).

c. *AFLC* — Deputy Chief of Staff, Logistics Operations (AFLC/LO).

d. *AFSC* — Deputy Chief of Staff, Logistics (AFSC/LG).

e. *USMC* — Deputy Chief of Staff for Installation and Logistics (Code LMA).

These OPRs will assure interservice consideration and staffing prior to change incorporation. Requisition and source of supply will be through normal publication distribution channels.

Chapter 5

SUPPORT EQUIPMENT (SE)

SECTION A — GENERAL

5-1. Purpose. This chapter establishes policy and procedures, terms, and conditions governing the identification, design, and acquisition of end items of SE. For multi-service programs, paragraph 5-4 also serves as JOA.

5-2. Scope. These procedures apply to SE procured to support systems equipment; applies to all military services, organizations, and personnel responsible for planning and contracting during all phases of the system life cycle.

5-3. Policy. SE planning requires support management attention throughout all phases of the life cycle to provide positive coordination with other program segments. The total SE requirements to support a system will be determined from data items from the systems contractor in accordance with procedures set forth in Armed Services Procurement Regulation (ASPR), and this chapter.

5-4. Details:

a. *General Procedures and Responsibilities.* Basic factors affecting SE development of requirements are: realism in quantity and quality of SE required; consideration of locations, pipeline, etc. timeliness of SE acquisition in consonance with the maintenance concept, maintainability analysis, optimum repair level analysis, and LSA. These requirements initially reflect only the general equipment required with provisions for subsequent progressive development of specific requirement for all support items. The SE program is developed concurrently with the ISP and is included as a part thereof. The SE program provisions thereof will become part of the contract documentation.

(1) Section B, as tailored, will be appended to the contract by the procuring activity to prescribe the procedures, terms, and conditions governing the identification, design, and acquisition of end items of SE required to support the end article on contract. The executive service (program project office) is responsible to carefully screen the requirements of section B and tailor the contents to their peculiar program and its needs.

(2) The procuring activity will utilize applicable DIDs in conjunction with DD Form 1423, CDRL to procure the necessary data required to maintain SE support for the end article.

(3) The procuring activity will be responsible for preparation of DD Form 1423 as outlined in ASPR and the timely acquisition of the data.

(4) Each using service will review the SE recommendation data (SERD) developed by the contractor, evaluate the existing resources, and determine SE requirements.

(5) The executive service shall keep the using services advised of any changes in the system programming that will affect SE support.

(6) Each using service will be responsible for selecting, programming, and funding its own SE requirements.

(7) SE will be obtained from the DOD inventory either through normal using service procedures or as part of the prime contract through the executive service.

(8) The procuring activity shall identify within the body of the basic contract those specific offices named on the CDRL (DD Form 1423) such as administrative contracting officer (ACO), approving authority, SE ordering activity, procuring activity, and requiring activity. In the event the above offices are not identified, all the duties delegated to them shall remain the full responsibility of the procuring contracting officer.

(9) The procuring activity shall assure that all (including computer equipment) software elements required to operate and support the SE are identified, developed, tested, and procured. Precautions must be taken to assure delivery is in usable format and with rights of data clearly defined and adequate for all anticipated use. The procuring activity will assure financial visibility of costs related to software acquisition by use of a WBS specifically tailored to determine these costs.

b. *Specific Procedures and Responsibilities*

(1) Upon DOD multiservice program decision, the executive service will be assigned by DOD.

(2) The executive service shall convene a conference to be attended by SE representatives from the using services to establish detailed guidance for contract clauses, DD Form 1423 content, and the solicitation (Request for Quotation (RFQ), Request for Proposal (RFP), or Invitation for Bid (IFB)) requirements.

(3) The executive service will issue the solicitation.

(4) Offerers will submit the SE plan with the response to RFQ RFP IFB

(5) The executive service will establish a Source Selection Evaluation Board (SSEB) in accordance with established procedures. Using service representatives will be members of the Board. Contractor proposals, including the SE plan will be evaluated by the SSEB and their recommendations forwarded for final selection through standard selection procedures.

(6) The executive service will convene a precontract guidance conference (optional at the request of the contractor).

(7) The executive service will award the system contract.

(8) The executive service may convene a postcontract guidance conference (optional)

(9) Participating services will review and annotate SERDs. Annotated SERDs reflecting required participating service information will be forwarded to the executive service.

(10) The executive service will resolve technical problems and all other conflicting information entered on the SERDs prior to the SE selection meeting. The resulting consolidated requirements will be forwarded with copies of each using service's SERDs to the ordering activity.

(11) The ordering activity will furnish one copy of each using service's SERD to the Resident Integrated Logistics Support Activity (RILSA) and one copy to the contractor along with the consolidated order for SE effort and/or hardware.

SECTION B — CONTRACT ITEMS

5-5. General Provisions:

a. *Purpose.* This section prescribes the procedures, terms, and conditions governing the design, identification, selection test, acceptance acquisition, and logistics support, of end items of SE and all computer Equipments required to support the end article on contract.

b. *Application:*

(1) Incorporation. Portions of this section shall be incorporated where applicable, by reference or appendage to contracts executed on behalf of the United States Government which provide for identification of SE and/or the delivery of an article and SE.

(2) Reference Publications. In addition to this regulation, the following documents, of the issue in effect on the date of the solicitation, form a part of this requirement to the extent specified herein.

DEPARTMENT OF DEFENSE

Cataloging Handbooks H4-1 and H4-2	Federal Supply Code for Manufacturers
Cataloging Handbook H6-1, Part 1	Federal Item Identification Guides Supply Cataloging
DOD 4100.38M	Provisioning & Other Preprocurement Screening Manual.

MILITARY

FED-STD-5	Standard Guides for Preparation of Item Descriptions by Government Suppliers
MIL-C-4150	Case, Carrying, Water-Vapor-proof.
MIL-C-45662	*Calibration System Requirements.*
MIL-D-1000	Drawings, Engineering and Associated Lists.
MIL-E-38793	Manuals, Calibration Procedure.
MIL-E-60106	Engineering Services, Calibration Equipment.
MIL-HDBK-300	Technical Information File of Support Equipment.
MIL-M-9868	Microfilming of Engineering Documents, 35mm; Requirements for.
MIL-N-18307	Nomenclature and Nameplates for Aeronautical Electronic and Associated Equipment.
MIL-P-9024	Packaging, Handling, and transportation in system/equipment acquisition.
MIL-Q-9858	Quality Program Requirements.
MIL-R-9441	Record, Aircraft Inventory
MIL-S-5944	Slings, Aircraft; General Specification for.
MIL-S-8512	Support Equipment, Aeronautical, Special; General Specification for Design of.
MIL-STD-12	Abbreviations for Use on Drawings and in Technical Type Publications.
MIL-STD-100	Engineering Drawing Practices.
MIL-STD-196	Joint Electronics Type Designation System.
MIL-STD-470	Maintainability Program Requirements for Systems and Equipments.
MIL-STD-480	Configuration Control — Engineering Changes, Deviations, and Waivers.
MIL-STD-785	Requirements for Reliability Program for Systems and Equipments.
MIL-STD-810	Environmental Test Methods.
MIL-STD-864	Ground Support Equipment Functional Classification Categories.
MIL-STD-8421	Air Transportability — General Requirements for.
MIL-STD-875	Type Designation System for Aeronautical and Aeronautical Support Equipment.
MIL-STD-1388	Logistic Support Analysis
MIL-STD-1472	Human Engineering Design Criteria for Military Systems Equipment and Facilities.
MIL-STD-1552	Provisioning Technical Documentation, Uniform DOD Requirements for.
MIL STD-1561	Provisioning Procedures, Uniform DOD.
MIL-T-28800A	... Equipment for Use with Electrical and Electronic Equipment; General Specification for

COMMERCIAL

ANSI Y32.16a	Reference Designation for Electrical and Electronic Parts and Equipment.
ANSI Y32.2	Graphic Symbols for Electrical and Electronic Diagrams.

(3) Other Documents.

DATA ITEM DESCRIPTION (DID)

DID NUMBER	***TITLE***
DI-A-6102	Support Equipment Plan (SEP)
DI-E-6120	Support Equipment Illustrations (SEI)
DI-E-6121	Support Equipment Installation Data
DI-F-6127	Support Equipment End Item Funding Report
DI-M-6153	Technical Manuals Commercial Literature
DI-P-6165	Support Equipment Delivery Schedule Delinquency Report
DI-S-6171	Logistic Support Analysis Record (LSAR)
DI-S-6176	Support Equipment Recommendation Data (SERD)
DI-S-6177	Calibration Measurement Requirements Summary
DI-V-6183	Consolidated Support Equipment List (CSEL)
DI-V-6184	Proposed Revision to the Support Equipment Exhibit
DI-V-6185	List of Standard Modified Hand Tools
DI-V-6186	Priced Support Equipment List
DI-V-7016	Provisioning and Other Preprocurement Screening Data
DI-S-7017	Logistics Support Analysis Plan

c. *Time Cycles.* Unless otherwise specified, the time cycles and limitations established by this document are maximums. When necessary to provide timely support by operational need dates, different time schedules will be mutually established at the guidance conference (see paragraph 5-6b).

d. *Subcontracts.* The contractor shall include applicable requirements of this chapter in all contracts with vendors for articles requiring identification of SE. He shall include the programming information with the purchase order contract as appropriate or as soon as such data are made available to him by the Government.

e. *Follow-On Contracts.* Procurement documents for follow-on contracts shall not require duplication of data except as provided in the appropriate DID.

f. *Repair Parts for SE.* Repair parts in support of SE procured on this contract will be documented and furnished in accordance with procedures set forth in the contract. The requirement for repair parts documentation for the SE item will be annotated on the SERD.

g. *Vendor Items.* The Government may at its option and after coordination with the prime contractor, effect direct contact with the prime contractor's vendors for the purpose of review, familiarization, and coordination on the selection of SE. Throughout the direct contact, actions shall not be taken that would infer or imply a commitment on the part of the Government or prime contractor. Any item selected for subsequent procurement at the time of review shall not be considered by the vendor to constitute a commitment or obligation on the part of the Government or prime contractor to order the selected items. Prime contractors and their vendors will further ensure that any contract entered into with vendors will include an appropriate clause whereby the vendor agrees to furnish directly to the Government information copies of such documentation as is prescribed in this document and give such assistance as may be necessary to enable the Government to select SE.

h. *Automatic Test Equipment (ATE).* The contractor shall insure that computer equipment used as SE (programmable test equipment) are planned, developed (using an approved computer language), acquired, employed, and supported to effectively, efficiently, and economically accomplish the assigned mission of the participating service. Such effort shall be in accordance with applicable contractual requirements.

5-6. Initial Information and Guidance:

a. *Initial Information.* With the executed copy of the contract, the procuring activity shall normally, on behalf of the United States Government, furnish the contractor complete program data on the employment and deployment of the end article on contract. Such information shall be revised as required to provide the contractor with the latest information on planned employment and materiel support for the end article on contract. In the event this is not furnished with the contract, such information shall be furnished to the contractor at the time of the guidance conference.

b. *Guidance Conference:*

(1) Precontract Guidance Conference. A request for guidance information may be made by an offerer as part of the precontractual source selection proceedings. Specific questions and or a proposed agenda of a guidance meeting shall be included in this request. The conference will be held within 15 days after receipt of an offer's request. At this conference, the procuring activity will provide complete instructions to all participating offerers regarding the extent of work to be performed under this document, submittal re-

quirements, approval times, applicability of specifications and standards other than those cited herein, and appropriate data requirements, especially the SEP (Support Equipment Plan), which outlines the contractor's plan for the SE program for an article, will be addressed.

(2) Postcontract Guidance Conference. The contractor shall recommend to the procuring activity a date for convening a postcontract guidance conference. Specific questions and/or a proposed agenda of the guidance meeting shall be included in this request. The date recommended shall be at the earliest possible mutually acceptable date but not later than thirty (30) days after award of the initial contract. The purpose of this conference will be to provide the contractor with policy direction and guidance concerning the requirements of this document and applicable DIDs.

(3) Supplemental Conferences. When it is determined that subsequent conferences must be held, the procuring activity and the contractor shall establish mutually acceptable dates for convening such conferences. When required, they shall be convened at the call of the procuring activity.

(4) Establishment of Guidance Conferences. The procuring activity shall establish a firm date for the conferences. The conference team shall be composed of responsible Government and offer contractor representatives. The conference shall be chaired by a representative of the procuring activity.

c. *Description of Procedures*. The following procedures will be utilized:

(1) Conference. Guidance conference occur between Government and the contractor as outlined in this document.

(2) SE Plan Submissions. The contractor shall prepare and submit, in accordance with the CDRL requirements, an SE Plan (DI-A-6102). Resubmissions of the plan shall be accomplished throughout the life of the contract to expand the content of the document to include and update all information required by the DID.

(3) SERD Submissions. The contractor shall prepare and submit a SERD (DID DI-S-6176) for each item of SE required to satisfy functional requirements identified. SERD submissions are a continuing requirement throughout the life of the contract. SE identified during the program initiation or prototype contractual efforts shall be reflected in the full scale development/production contract. For those items and quantities not ordered in the program initiations/prototype/full scale development contracts, the ordering activity may authorize the contractor to proceed with the design, development, and manufacture or procurement portion of the program under the production contract. For production contracts on weapon systems or subsystems which have been covered by SERDs during previous development or production contracts for the same end article, resubmission of SERDs are not required unless new requirements are identified. Where one SE item may satisfy two or more different functional requirements, and the previous SERD submittal does not reflect this fact, resubmittal of the SERD using the same item number is required indicating the new/additional information.

(a) Selection and Description of Items. Selection and description of items shall conform to the following requirements. To promote standardization of SE within the Government, the contractor shall consider the following order of priority in preparing recommendations:

(1) FIRST: Equipment defined by current Government specifications or modification of such equipment.

(2) SECOND: Off-the shelf commercial equipment currently in the Government inventory for which procurement data are available.

(3) THIRD: Other off-the-shelf commercial or modified commercial equipment.

(4) FOURTH: Proposed equipment to be developed by the contractor, subcontractor, or associate contractor. The contractor shall identify any items of GFE which are to be incorporated into the proposed item of SE. (see chapter 6).

The contractor in preparing his recommendations shall obtain from the procuring activity the Technical Information File (MIL-HDBK-300) for his use in determining whether a SE functional requirement can be fulfilled by an item of equipment which is already in Government inventory. Participating services lists of preferred SE shall also be consulted.

(b) Exclusions. Unless otherwise specified in the contract, SERDs shall not be prepared for the following items or classes of equipment:

(1) Common powered and non-powered handtools.

(2) Housekeeping items.

(3) Office furniture and similar equipment which are required as indirect support and are defined in applicable allowance lists.

(4) Common production tools and tooling, for example, lathes, drill presses, plating equipment, grinders, induction heaters, etc.

(5) Items which are used only by the contractor.

(6) Personal equipment, for example, headsets, microphones, etc.

(7) Offline ADP equipment.

(c) Initial SERD Submissions. Initial SERDs shall be submitted by the contractor not later than 30 days or as otherwise authorized after receipt of the funding authorization. The procuring activity may after review of the initial submission (or as might become necessary at any subsequent time), alter the recommendation. The description of an item either procurement or engineering critical will actuate a close liaison between agencies designated by the system program director or appropriate Government management agency, ensuring effective followup of the item of SE involved in accordance with programming requirements.

(d) Subsequent SERD Submission. Unless otherwise specified in the contract, subsequent SERDs shall be submitted on such a schedule (normally at 30-day intervals) to provide the Government sufficient time to review the proposed item and authorize procurement and delivery to support the first end article delivered to the Government. More frequent submissions may be made under mitigating circumstances, for example, engineering procurement critical or safety of flight.

(e) SERD Review. SERDs will be reviewed by

the Government and appropriate portions returned to the contractor not later than 60 days after receipt by the SE approving authority.

(4) Contractor SERD Actions. Upon receipt of the approved SERD from the Government, the contractor shall, as authorized by the ordering activity, initiate the actions indicated in the SERD, such as:

(a) Changes in design characteristics, if indicated on Figure 1a of the SERD.

(b) Establish procedures to ensure continuous and close liaison with the Government during the development, procurement of designated SE critical items.

(c) Prepare end item specifications, or other specifications, in accordance with the contract requirements.

(d) Prepare SEI in accordance with DID DI-E-6120.

(e) Prepare technical manuals in accordance with DID DI-M-6153.

(f) Prepare Maintenance requirements cards in accordance with the contract requirements.

(g) Prepare CMRS (on system component and/or SE item) in accordance with DID DI-S-6177.

(h) Prepare Installation data in accordance with DID DI-E-6121.

(i) Prepare repair parts provisioning technical documentation in accordance with MIL-STD-1552 (see chapter 4).

(j) Proceed with design and fabrication procurement in quantities indicated on figure 1b of the SERD.

(k) Compile data for periodic submission of the CSEL in accordance with DID DI-V-6183.

5-7. Data Requirements: *Types of Data.* As specified on the contract data requirements list (DD Form 1423), the following SISMS data item descriptions explain types of data to be provided:

a. *SE Recommendation Data (SERD).* The contractor shall prepare and submit SERDs in accordance with DID DI-S-6176.

b. *Consolidated SE List (CSEL).* The contractor shall prepare and submit CSEL in accordance with DID DI-V-6183.

(1) Initial. Not later than thirty (30) days after receipt of approved SERDs from the Government, the contractor shall furnish a CSEL reflecting all items of SE selected as well as those not selected.

(2) CSEL Revisions. At 60-day intervals, the contractor shall prepare revised or additional pages reflecting changes to items previously listed, or the addition of new items, for which the contractor has received an annotated SERD. Government decisions will continue to be reflected on the CSEL. All CSEL revisions shall include change sheets to the Revision Index (identified as Sequence 3). Revision sheets for Sequences 3 through 10, as applicable, shall be submitted whenever more than ten items are involved in the revisions. The revision submission which coincides with the semiannual CSEL reissue referred to in paragraph 5-7b(3), shall be incorporated as part of the reissue. If no approved disapproved SERDs have been received from the Government within the last 60-day period, a negative report will be submitted by the contractor.

(3) CSEL Reissues. Unless otherwise specified, the contractor shall update and reissue the CSEL every 180 days for the purpose of incorporating the revisions submitted in accordance with paragraph 5-7b(2). The reissue precludes a requirement for submission of concurrent revision. If no revisions have been effected against the CSEL during the 180-day reissue cycle, no reissue is required and a negative report shall be submitted. All revisions shall be referenced to permit ready identification. A reissue shall always be submitted within 30 days after award of a follow-on contract for additional end articles. This reissue establishes a new cycle for the issuance of revisions and reissues.

(4) CSEL for SE Selection Review Meetings. In those instances when a SE selection review meeting must be held (paragraph 5-9d), the contractor shall make available a CSEL Reissue for the use of all attendees at the meeting. This CSEL Reissue shall include all items of SE previously submitted by the contractor and approved, disapproved by the Government. The contractor shall identify the list in the heading as the "Consolidated Support Equipment List for SE Selection Review Meeting." The contractor shall provide copies of the list as specified by the Government.

c. *CMRS (Calibration Measurement Requirements Summary).* The CMRS shall be prepared in accordance with DID DI-S-6177 and as specifically authorized in the SERD by the Government. Initial submission of the CMRS shall be not later than 120 days after funding authorization for required effort. Revisions shall be submitted progressively, within system (Category 1) or as SE measurement requirements become know.

d. *SE Illustrations (SEI).* The contractor shall prepare SEI in accordance with DI-E-6120, but only for those items specified by the Government on the approved SERD. SEI data shall not normally include common tools found in the standard machine shop, component parts or subassemblies of SE end items, kits, sets of tools, fixtures for manufacturing or depot maintenance use, slings adapters, small containers, cabinets, or items of supply with status classification of "obsolete."

(1) SEI Acceptance. SEI furnished in accordance with this requirement shall be subjected to inspection and approval in accordance with applicable specifications.

(2) Preparation for Delivery (see chapter 8):

(a) *Packaging.* The DD Forms 1786 and illustrations shall be packaged flat between two pieces of domestic fiberboard.

(b) *Packing.* Unless otherwise specified, the product shall be packed in containers which (together with packaging and wrapping) are acceptable by common carriers for safe transportation.

(c) *Marking.* The following information shall appear on the outside of each shipping container:

Support Equipment Illustrations

Name of Contractor ____________________

Contract or Order Number ____________________

End Article System Application ____________________

e. *SEDSDR (SE Delivery Schedule Delinquency Report).* This report shall be prepared in accordance with DID DI-P-6165.

f. *Revisions.* Revisions to the approved delivery schedule shall only be submitted when:

(1) New SE items are added (same time frame as above).

(2) Quantities are revised (same time frame as above).

(3) Any item is anticipated to become delinquent (as soon as known).

(4) Any item has actually become delinquent (within 5 days after the actual delinquency and continuing at the 30-day intervals until there are no delinquent items).

g. *LSMHT (List of Standard Modified Hand Tools).* This list shall be prepared in accordance with DID DI-V-6185 and submitted not later than 120 days prior to delivery of the first end article on the contract. Revisions to the list shall be submitted as required.

h. *PSEL (Priced SE List) and SE Exhibit.* The PSEL shall be provided in accordance with DID DI-V-6186 and procedures indicated in paragraph 5-12a. The approved and agreed upon PSEL (with cancellation addendum, if any) results in the SE Exhibit. Applicable procedures are indicated in paragraph 5-12b. Revisions to the SE Exhibit will be provided in accordance with DID DI-V-6184 and procedures indicated in paragraph 5-12b.

i. *SEIFR (SE End Item Funding Report).* This report shall be prepared in accordance with DID DI-F-6127 and procedures indicated in paragraph 5-13. The report reflects the funding status of each SE contract line item, as well as each different funding citation, in the end article contract. This report shall be submitted by the 10th day of each month.

j. *SEP (SE Plan).* To be provided in accordance with DID DI-A-6102.

(1) Plan, Initial Submission. Concurrently with and as a part of, the contractor's proposal/quotation for the end article program.

(2) Plan Revisions. During negotiation of the end article contract and as required to reflect end article or SE program changes. Revisions also may result from the guidance conferences convened pursuant to paragraph 5-6b.

k. *SEID (SE Installation Data).* SEID shall be prepared in accordance with DID DI-E-6121 as authorized by the Government in approved SERDs for end items of SE requiring installation in existing or planned shipboard or shore-based facilities. Initial SEID shall be submitted not later than 30 days after release of the SE item for fabrication. Revisions shall be submitted within 30 days after release of any change in fabrication.

l. *SE Nomenclature.* To be provided in accordance with Cataloging Handbook H6-1.

m. *Data.* The following types of data are to be provided:

(1) SE Engineering Data Drawings and Associated Lists — In accordance with contract requirements.

(2) SE Preservation and Packaging — in accordance with contract requirements.

(3) SE Logistics Support Analyses — The contractor shall prepare a LSA for items of SE as indicated in the Government approved SERD. The analysis will be specifically indicated to the contractor, and may be selected from DIDs DI-S-7017 or DI-S-6171.

(4) SE Technical Manuals — In accordance with DID established by the procuring activity.

(5) SE Repair Parts Provisioning Documentation — The contractor shall prepare and submit to the Government, SE repair parts provisioning documentation/lists for each SE end item specifically authorized on approved SERDs. The provisioning documentation/lists shall be prepared in accordance with MIL-STD-1552 (see chapter 4).

(6) SE Provisioning Screening. The contractor shall perform SE provisioning screening for each SE end item prior to submission of the SERD. Such provisioning screening data shall be prepared in accordance with DID DI-V-7016.

(7) SE Item Description. The contractor shall prepare and submit SE item descriptions for each SE end item specifically authorized on approved SERDs. The SE item descriptions shall be prepared and submitted in accordance with FED-STD-5.

5-8. SE Identification and Design:

a. *Funding Requirements and Authorization.* Prior to execution of the contract, the contractor shall advise the SE approving authority through the PCO the estimated funds required for nonrecurring engineering effort. Additional funding requirements shall be shown separately and indicate the period to be covered for SE design effort, SE sustaining engineering effort, and cost of preparing each data item estimated by the contractor to be required herein and prescribed in paragraph 5-7. The SE Approving Authority will, after receipt of the funding estimate, and contract award, issue, or cause to be issued, appropriate funding authorization documents to cover the services and data to be authorized, or advise the contractor that effort is not required under this contract item.

b. *SE Identification.*

(1) End Article Analysis. The contractor shall investigate requirements for SE, as substantiated by end article LSA in accordance with DI-S-7017 (see chapters 3 and 6) when specified in the contract. If SE design and procurement manufacturing leadtime considerations dictate recommending the SE item to the AA in order to meet test operational requirements before the LSA has been formally documented, the leadtime shall dictate such submission. Upon completion of the LSA, the contractor shall immediately revise his SE submission if the analysis reveals changed SE requirements.

(2) SE for Government-Furnished Components. Normally, SE strictly related to a Government-furnished component installed in the end article is excluded. However, items that are required, due to peculiarities of the installation of the Government-furnished component in the end article, are required to be investigated and submitted for consideration.

(3) Selection Criteria. To promote standardization of SE within the Government, the contractor shall consider the following order of priority in preparing recommendations. First, equipment defined by

current Government specification or modification of such equipment. second. privately developed commercial equipment currently in the Government inventory which have been qualified to the requirement and for which procurement data are available. third. other such privately developed commercial or such modified equipment which can be qualified. Fourth. proposed equipment to be developed by the contractor. sub-contractor or associated contractor.

(4) Government Inventory Information. The contractor in preparing his recommendations. shall obtain from the procuring activity the Technical Information File (MIL Handbook-300) for his use in determining whether a SE functional requirement can be fulfilled by an item of equipment which is already in Government inventory. Participating service lists of preferred SE shall also be consulted.

c. *SE Design.* SE design. drawings. and detailed specifications shall be in accordance with the following specifications. as appropriate to the nature of the particular item. except that items required solely for depot level use may be designed. and drawings prepared in accordance with the manufacturer's normal commercial practices.

MIL-C-4150	Case. Carrying. Water-Vapor-proof.
MIL-D-1000	Drawings. Engineering and Associated Lists.
MIL-N-18307	Nomenclature and Nameplate for Aeronautical Electronic and Associated Equipment.
MIL-S-5944	Slings. Aircraft; General Specification for.
MIL-S-8512	Support Equipment. Aeronautical. Special. General Specification For Design of.
MIL-STD-12	Abbreviations for Use on Drawings and in Technical Type Publications.
MIL-STD-100	Engineering Drawing Practices.
MIL-STD-196	Joint Electronics Type Designation System.
MIL-STD-470	Maintainability Program Requirements for Systems and Equipments.
MIL-STD-785	Requirements for Reliability Program for Systems and Equipments.
MIL-STD-810	Environmental Test Methods.
MIL-STD-875	Type Designation System for Aeronautical and Aeronautical Support Equipment.
MIL-STD-882	System Safety Program.
MIL-STD-1472	Human Engineering Design Criteria for Military Systems Equipment and Facilities.
MIL-T-28800A	Test Equipment for Use with Electrical and Electronic Equipment; *General Specification for*
ANSI Y32.16a	Reference Designation for Electrical and Electronic Parts and Equipment.
ANSI Y32.2	Graphic Symbols for Electrical and Electronic Diagrams.

NOTE: Additional specifications may be cited in the contract. as appropriate.

d. *Use of the SERD:*

(1) Contractor Furnished SE. Requirements for design. development. fabrication. procurement. test. and initial quantities of SE shall be established through submission and approval of the SERD. Changes in design information. if required. will be indicated on an approved SERD Figure 1a returned to the contractor. Government decisions on SE items are reflected on an approved copy of the SERD Figure 1b returned to the contractor. Information required in addition to that contained in the SERD may be requested. where necessary. by the SE AA prior to granting the contractor authorization to proceed. The additional data my be in the format of an EIS.

NOTE: SE identified during the validation phase of the end article life cycle shall be submitted as SERDs in the full scale development. production contract. For those items and quantities not ordered in previous phases. the procuring activity may authorize the contractor to proceed with the design. development. and manufacture or procurement portion of the program under the production contract.

(2) Government Furnished SE. Approval by the Government of the entry "G". block 12. of the SERD indicates that the Government intends to provide the item vice contractor furnished. Items which are determined to be properly Government furnished. but which the Government is unable to provide on a timely basis. may be authorized for contractor procurement. In such instances. the AA will provide appropriate procurement data and recommended sources.

(3) Logistics Support for SE. Logistics support requirements for approved items of SE are initiated through the submittal and approval of appropriate information on the SERDs. Certain information pertaining to logistics support requirements for individual SE items is proposed by the contractor on the SERDs. The Government approves. revises. and/or adds logistics support element information on the SERDs and authorizes the contractor. through the ordering activity to initiate required logistics support action. Such action includes the preparation of technical manuals. maintenance requirements cards. calibration measurement requirements summary. provisioning screening data. repair parts provisioning documentation. item descriptions. installation data and LSA planning data when applicable and authorized by the Government on the approved SERD.

e. *Design Changes:*

(1) Class I Changes. If. after establishment of a firm configuration of an item of SE. it is considered necessary to change the design. eliminate. supersede. or add items of SE because of any of the following conditions. the contractor shall select and initiate the appropriate action as described herein. A firm configuration is established on the signing of the DD Form

250 for the first item. After submission of the firm price proposal but prior to signing of the DD Form 250 for the first item, the contractor may make category D or E changes without submission of an ECP provided these changes do not affect or alter capability or negotiated cost of the SE item.

(a) CATEGORY A:

1. Condition: Change in end article dictates requirement for new item(s) of SE. Does not affect existing items.

2. Action: The end article ECP shall be accompanied by a SERD for each new item. The SERD will be processed by the Government in conjunction with ECP processing; action on each SERD will be taken concurrent with the ECP action to the contractor.

(b) CATEGORY B:

1. Condition: Change in end article dictates requirement for new item(s) of SE which completely supersedes existing item(s). Superseded item(s) cannot be brought to configuration of new item(s).

2. Action: The end article ECP shall be accompanied by a SERD for each item. The SERD will be processed by the Government in conjunction with the ECP action to the contractor.

(c) CATEGORY C:

1. Condition: Change in end article dictates requirement for new item(s) of SE which supersedes existing item(s). Superseded item(s) may be modified to configuration of new item(s), retaining, if possible, the capability of the superseded item.

2. Action: The end article ECP will be accompanied by a separate ECP for each item of SE requiring modification. These ECPs shall indicate the modifications necessary to make the SE item compatible with the new end item configuration and will be processed concurrently with the end article ECP. If the ECP to the end article establishes a requirement for new SE a new SERD will be processed.

(d) CATEGORY D:

1. Condition: Changes to an end item of SE are necessary to correct a design deficiency in the support equipment.

2. Action: Submit SE ECP prepared and submitted in accordance with MIL-STD 480, accompanied by a SERD reflecting the new item. If modification is required, follow procedures for category C and submit a separate SERD reflecting the general description of the modification material required.

(e) CATEGORY E:

1. Condition: Changes to an end item of SE are necessary to implement a design improvement. All items will not necessarily be changed.

2. Action: Submit SE ECP, prepared and submitted in accordance with MIL-STD-480, accompanied by separate SERDs for the old item as well as the new. The Government will determine whether all or part of the delivered items will be modified. If modification is required, follow procedures for category C, and submit a separate SERD reflecting the general description of the modification material required.

(2) Class II Changes. Class II changes shall be submitted to the ACO for review and concurrence in classification.

5-9. SE Acquisition:

a. *Initial Order.* The initial order is accomplished by return of the approved SERD and issuance of an order by the ordering activity. The quantity of SE items to be acquired shall be in accordance with Figure 1b.

b. *Follow-On Orders.* Based on a review of the CSEL or SERD by the Government, the contractor may be furnished an order for items and quantities of SE which the Government determines should be procured from the contractor. The contractor will proceed to produce or procure the items and quantities so ordered.

c. *Release/Cancellation Order:*

(1) Release. In the event the contractor has not received a response within seventy-five (75) days from date of the initial submission of a SERD, the ordering activity, upon request from the contractor and subject to availability of funds, may issue an order for the SE item(s) in quantities recommended by the contractor on the SERD, or as otherwise determined by the ordering activity. The contractor will notify the AA and the RA in writing (electrical transmission preferred) seven (7) days prior to the effective automatic order date.

(2) Cancellation. Any changes, occasioned by subsequent directives, which result in cancellation/termination charges will be processed and settled as provided for in the cancellation/termination clause of the contract. The contractor, in effecting such order, shall not exceed the funds authorized for the SE items. When authorized funds are insufficient, the contractor, shall advise the ordering activity.

d. *SE Selection Review Meeting:*

(1) Establishing Requirement. A SE selection review meeting may be held at the option of the AA/RA when it is determined that such a meeting is necessary due to program changes, engineering changes to the end article which would cause significant change in items and quantities of SE recommended by or ordered from the contractor, or other reasons subject to mutual agreement between the contractor and Government.

(2) Contractor Preparation. The contractor shall recommend to the AA a date and place for holding the SE selection review meeting. The contractor must ensure that the recommended date will allow sufficient time for ordering of the SE prior to delivery of the last end article. The contractor shall have available for the meeting all technical data including SERDs, specifications, and drawings that are available for the CFE items of SE listed on the CSEL, as well as for those items for which requirements developed subsequent to the submission of the last CSEL revision. The AA shall specify those articles desired for inspection during the review meeting. The contractor will advise the AA of those items that cannot be made available and reasons therefore. In the event the contract does not contain a specification covering drawings, those drawings used by the contractor for manufacturing or procurement purposes will be suitable for review purposes.

(3) The meeting. The government team shall review the specifications and supporting data in conjunction with the CSEL furnished by the contractor. The team shall make whatever adjustments are necessary, in items and quantities of SE previously ordered

from the contractor to meet current program requirements commensurate with the terms of the contract.

(4) Conclusion. The contractor shall, not later than fifteen (15) days after the meeting, in accordance with the quantities and destinations specified in the DD Form 1423, furnish the activities revised copies of the SERD(s) and CSEL reflecting action taken. Within fifteen (15) days after receipt of the revised copies of the SERD(s) CSEL or as negotiated at the guidance conference, the procuring activity shall provide the contractor written authorization to proceed and or continue with the design fabrication or procurement of the items and quantities of the SE selected.

f. *Changes to Orders.*

(1) Additions. Unless otherwise negotiated, the Government may at any time, but not later than the scheduled delivery of the last end article under the contract, order additional SE. Delivery of additional items or quantities of SE included in the order or revision thereto, shall be made in accordance with a schedule agreed upon by the Government and the contractor.

(2) Deletions. The Government may at any time, in writing, delete items of SE on order. Charges with respect to any items and quantities of SE deleted will be processed and settled as provided in the contract cancellation terms.

5-10. Delivery of Support Equipment:

a. *Time of Delivery.* The contractor shall propose delivery schedules in accordance with DID DI-P-6165 within thirty (30) days after receipt of an order from the Government. Within fifteen (15) days after receipt, the Government will approve, or will negotiate to revise, the contractor's proposed delivery on a specific SE end item basis. Failure to agree on the delivery of a specific SE end item(s) will not affect the remaining items when the Government and the contractor have reached an agreement. The approved schedule will be incorporated into the contract at the time of incorporation of the Priced SE List. The contractor shall not deliver SE more than ninety (90) days before delivery of the training equipment first end article, or the date of scheduled delivery, unless SE delivery is specified or approved by the Government. The early delivery of these items of SE normally will be limited to ship/base installed items.

b. *Point of Delivery.* The ordering activity shall notify the contractor, in writing, as to the destination of SE to be furnished hereunder at least 120 days in advance of the scheduled delivery, or on a date mutually agreed upon by the contractor and the ordering activity. When believed to be in the best interest of the Government, the contractor shall recommend to the ordering activity a schedule for shipment of SE on order with the contractor but manufactured in plants other than the contractor's plant or plants. When approved and directed by the ordering activity, the contractor shall instruct the manufacturer to make direct shipment to the designated destination. The contractor shall not deliver any SE unless the shipping papers, including the packing sheets, fully identify each item to be shipped in accordance with the identification established for such items, except that the contractor may shorten the description by listing the principal noun and type designators in addition to one or two descriptive modifiers. Unless otherwise authorized by the SE ordering activity, the contractor shall not ship equipment for operational or training purposes without an NSN which shall be furnished by the Government prior to required delivery.

c. *Delinquency Delivery Report.* The contractor shall furnish delinquency delivery reports for SE in accordance with DID DI-P-6165.

d. *Preservation, Packaging, Packing, and Marking Requirements.* Preservation, packaging, packing and marking applicable to SE shall be provided in accordance with the contract requirements (chapter 8).

5-11. SE For Training. The procedures, terms, conditions, and delivery of SE selected for use as training equipment or to support training equipment shall be in consonance with the applicable training need date cited in the contract. To assure timely delivery of SE for training equipment, the contractor shall exercise special surveillance over the procedures, terms, conditions, and delivery of such SE as outlined in this document. Such special surveillance requires that the contractor clearly identify on the initial identification document (SERD) those SE items required for training (see chapter 13).

5-12. Pricing:

a. *Priced Support Equipment Lists (PSELs) and Revisions Thereto.* The PSELs reflecting the material and effort covered by the Government orders shall be submitted to the ACO by the contractor within 60 days after receipt of the order or as negotiated between the procuring activity and the contractor. A separate priced list shall be submitted by the contractor for each item or subitem under this contract.

b. *SE Exhibits.* If the item prices and quantities contained in the PSEL and in the cancellation addendum, if any, are acceptable to the Government, the list shall be incorporated by supplemental agreement into the contract as the SE exhibit. If the PSEL is not acceptable as submitted, prices shall be established by agreement. Failure to agree upon items, quantities, or prices to be included in the SE exhibit shall be a dispute concerning a question of fact within the meaning of the clause of the contract entitled "Disputes;" however, such dispute shall be limited to the affected items and shall not delay the establishment of the remainder of the list as the SE exhibit.

c. *Revision of Exhibit.* Each 60 days, as necessary, beginning with the establishment of the SE exhibit and continuing until completion of deliveries of all items to be delivered under the contract, the contractor shall prepare and submit to the ACO a proposal for revising the SE exhibit to date covering effort, new items, or increased or decreased quantities of items. Each such proposal shall conform to the format of DID DI-V-6184 to include proposed price and indicate all changes and revisions approved by the Government. Upon the establishment of firm prices in accordance with the provisions of b *above*, the revised SE exhibit will be incorporated by supplemental agreement to the contract.

5-13. Funding. The contractor shall submit report of funding requirements and status in accordance with DID DI-F-6127. The report shall be submitted via the ACO to the destination specified on the DD Form 1423. The report shall cover each SE contract line item, as well as each different funding citation, in the end article contract. The report shall be submitted to

the ACO by the tenth of each month and shall reflect a cut-off date of funding status as of the last working day of the previous month.

APPENDIX D

SUMMARY OF JOINT SERVICE GUIDELINES FOR AUTOMATIC TEST EQUIPMENT ACQUISITION

This appendix summarizes two Joint Service guides prepared under the auspices of the Joint Logistics Commanders (JLC) Panel on Automatic Testing. Those guides are:

- "Joint Service Automatic Testing (AT) Acquisition Planning Guide," 19 March 1981.
- "Joint Service Weapon System Acquisition Review Guidelines for Automatic Testing (AT)," 19 March 1981.

Both guides focus on automatic testing, including design for testability, built-in test, off-line automatic test equipment (ATE), and test program sets (TPSs).

The planning guide provides an overview of the acquisition activities as they relate to automatic testing (see Figure D-1). It stresses the application of logistic support analysis, in accordance with Military Standard 1388, as the most important acquisition activity for the development and implementation of the automatic testing support system; it points out the preference for general-purpose ATE over system-peculiar ATE to restrict the variety of ATE in the inventory; it encourages standardization of ATE hardware and software within and among the Military Services; and it suggests that environmental specifications be relaxed, when practical, to permit use of commercially available ATE but warns about the need to ensure logistic support of commercial equipment. The planning guide describes the major activities in each phase of the weapons system acquisition program. In the concept exploration phase, tradeoff analysis and selection of a cost-effective ATE scenario are identified as the most critical activities. It suggests that models such as the Support Equipment Selection Analysis (described in Appendix E) be used in ATE scenario development. In the demonstration and validation phase, logistic support analysis and determination of automatic testing requirements are the central activities. Automatic testing requirements include design for testability and built-in test; with respect to ATE, the focus is on unit-under-test/built-in-test/ATE

compatibility and further refinement of the ATE scenario analysis conducted earlier. The major activities in the full-scale engineering development phase are refinement of the logistic support analysis and level of repair analysis for each configuration item. Once these activities have been accomplished, the test requirements analysis can be completed and test requirements documents can be prepared for each unit-under-test. At that time, final ATE selection or development specifications should be completed so that development of test program sets can be initiated. This phase is to be completed with various test and evaluation efforts and demonstrations. The guide continues by describing various activities in the production phase with emphasis on configuration management requirements for TPSs.

The second guide lists some of the key questions to be considered at appropriate review points in the weapons system acquisition process. Those questions are illustrated in Table D-1.

FIGURE D-1. FUNCTIONAL FLOW OF ACQUISITION ACTIVITIES

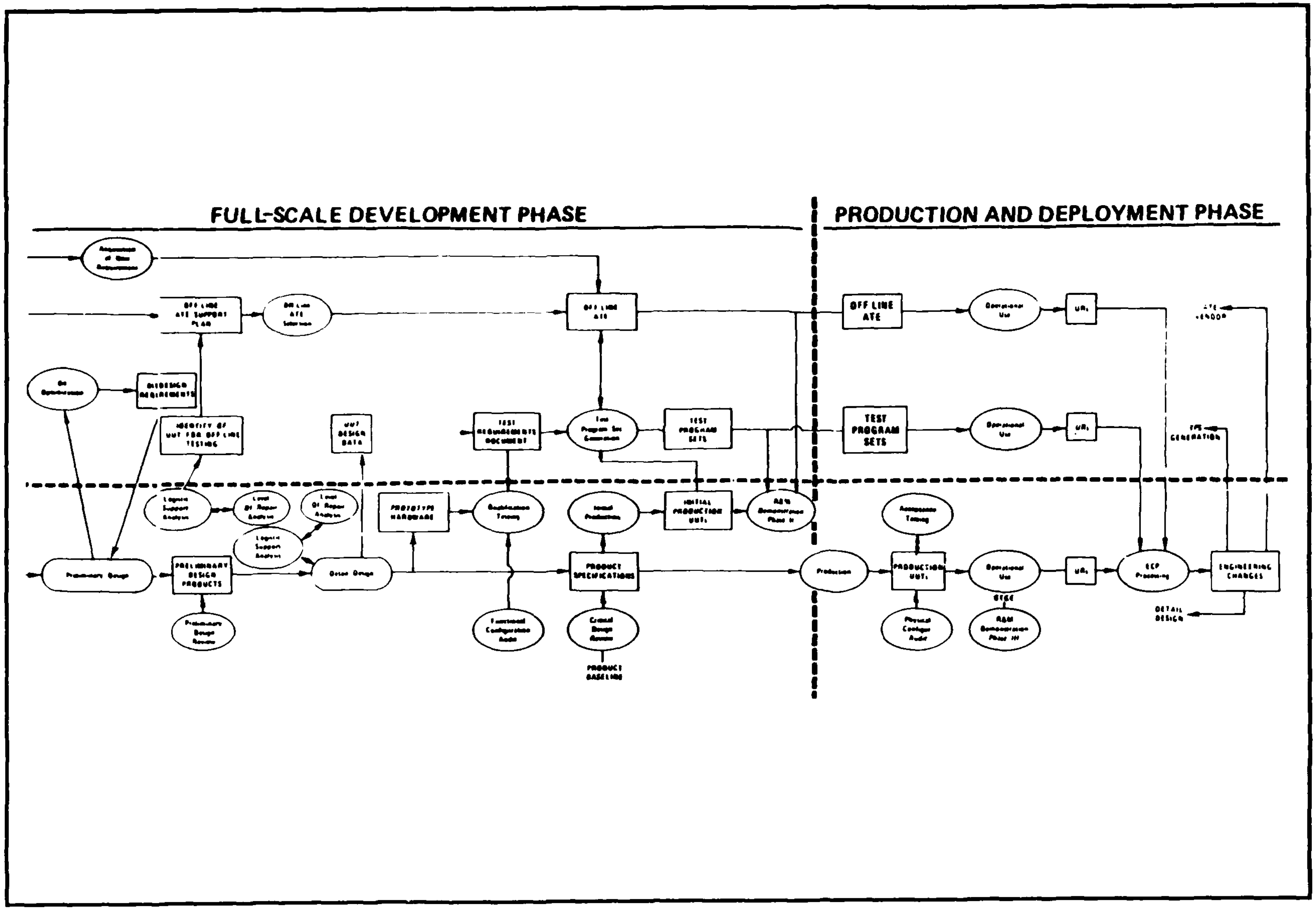

FIGURE D-1. FUNCTIONAL FLOW OF ACQUISITION ACTIVITIES (CONTINUED)

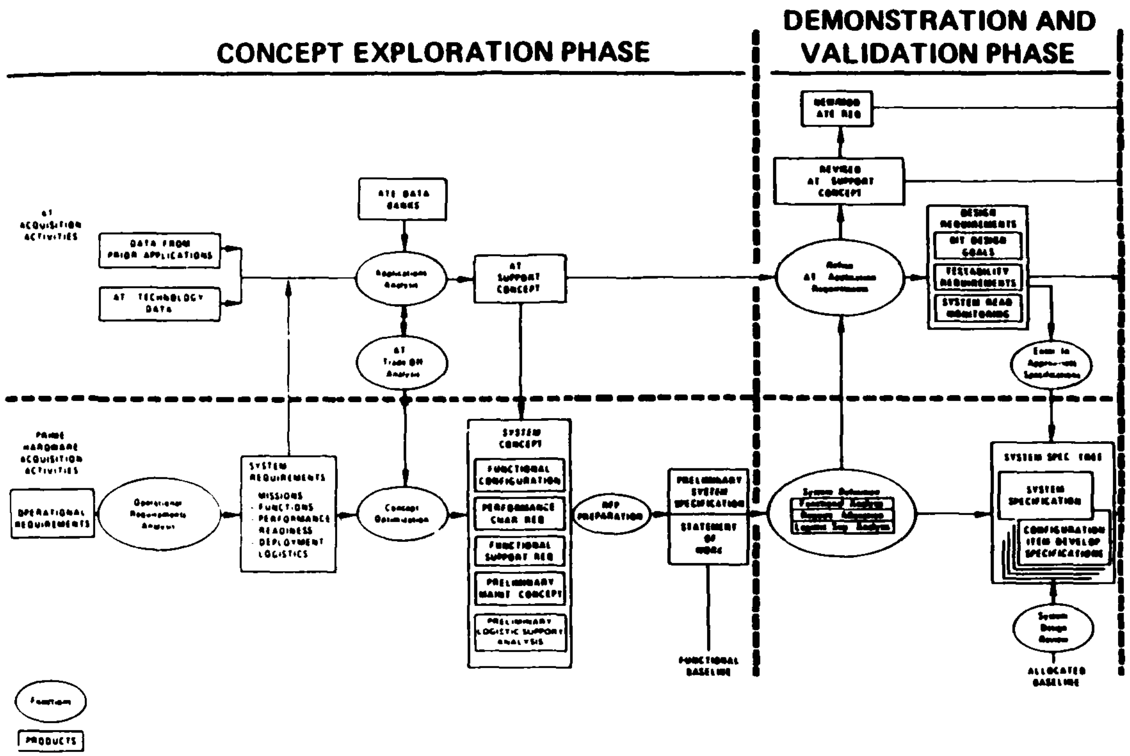

TABLE D-1. WEAPONS SYSTEM ACQUISITION REVIEW GUIDELINE MATRIX

DOCUMENTS	MILESTONE 0 (MENS Approval) Concept Exploration	MILESTONE 1 (DSARC I) Demonstration & Validation	MILESTONE 2 (DSARC II) Full-Scale Development	MILESTONE 3 (DSARC III) Production
Mission Element Needs Statement (MENS)	DoDD 5000.1 DoDI 5000.2 AR 1000-1 SECNAVINST 5000.1 AFR 57-1 AFR 800-10	As in Concept Exploration	As in Concept Exploration	
DCP	DoDI 5000.2 AR 1000-1 OPNAVINST 5000.42A NAVMATINST 5000.23 AFR 800-2	As in Concept Exploration	As in Concept Exploration	
Project Master Plan	AR 70-27 AR 700-127/DARCOM Supp NAVMATINST 5000.11B AFR 80-2 AFR 800-2 AFR 800-8 AFLC/AFSC P 800-34 AFSCP 800-3 C-1	As in Concept Exploration	As in Concept Exploration plus Joint *Service SISMS Directive*	As in Concept Exploration and Full Scale Development Plus AFLC/AFSCR 800-4
Support Concept	DoDD 4100.35 DoDD 4140.40 DoDD 5000.39 AR 70-1 AR 71-9 NAVMATINST 3960.9A NAVMATINST 4000.20B AFR 26-12 AFR 800-8 AFLCR 400-21	As in Concept Exploration	As in Concept *Exploration plus* DoDDs 3005.5, 4140.2, 4140.21 and 4140.24 DoD War Reserve Requirements	

TABLE D-1. WEAPONS SYSTEM ACQUISITION REVIEW GUIDELINE MATRIX (CONTINUED)

DOCUMENTS	MILESTONE 0 (MENS Approval)	MILESTONE 1 (DSARC) I)	MILESTONE 2 (DSARC II)	MILESTONE 3 (DSARC III)
	Concept Exploration	Demonstration & Validation	Full-Scale Development	Production
Support Concept (Cont'd)	AFLC/AFSCP 800-34 MIL-STDs 785A, 1390 and 2077 C-2		AFR 66-5 AFR 67-19 AFM 67-1 AFR 400-24	
Supportability Problem Assessment (Generic Term)	AR 700-127/DARCOM Supp NAVMATINST 4000.20B AFLC/AFSCP 800-34 C-3	As in Concept Exploration V-4	As in Concept Exploration	
Development Proposal (Navy Peculiar Term Equivalent Documentation Prepared in Army & AF)	AR 70-27 OPNAVINST 5000.42A NAVMATINST 5000.22A Checklist IV-4, VIII-3, 4, & 5 AFR 800-2 C-4			
Advanced Procurement Plan (Also referred to as Procurement Plan or Acquisition Plan)	DAR AR 70-1 AR 70-27 APP 1-2100 SECNAVINST 5000.1 AFR 800-8 AFLC/AFSCP 800-34 AFLCR 70-15 C-5	As in Concept Exploration plus DoDI 4140.41 AFR 800-22 AFLC/AFSCR 800-31 V 9	As in Concept Exploration and Validation	

TABLE D-1. WEAPONS SYSTEM ACQUISITION REVIEW GUIDELINE MATRIX (CONTINUED)

DOCUMENTS	MILESTONE 0 (MENS Approval)	MILESTONE 1 (DSARC I)	MILESTONE 2 (DSARC II)	MILESTONE 3 (DSARC III)
	Concept Exploration	Demonstration & Validation	Full-Scale Development	*Production*
LSA Records	DoDD 5000.39 AR 700-127/DARCOM Supp NAVMATINST 4000.20B AFR 800-8 AFLC/AFSCP 800-34 MIL-STD 1388-1-2 C-6	NAVMATINST 1500.2C Plus As in Concept Exploration V-2	As in Concept Exploration and Validation F-1	As in Concept Exploration and Validation P-3
Specifications	DoDI 4120.3 DoDI 4120.20 DoDM 4120.3M DoD SD-1 DoDD 5500.2 AFR 73-1 AFR 800-27 MIL-STDs 490 & 1326 C-7	MIL-STDs 415, 1345, 1519, 2076 & 2077 NAVMATINSTs 3960.9A & 4120.105 Plus As in Concept Exploration V-1	MIL-STDs 961, 962 and 1399 IEEE STD 488 Plus As in Concept Exploration and Validation F-3	
Preliminary Logistics LCC Report	DoDD 5000.28 AR 11-18 DA PAM 11-25 AR 700-18 NAVMATINST 4000.20B AFR 800-11 with AFLC/AFSC Supps C-8			
Procurement Request		DAR DARCOM-R 11-27 NAVMATINST 3900.3B AFR 800-8 AFLC/AFSCP 800-34 V-7	As in Validation F-9	

TABLE D-1. WEAPONS SYSTEM ACQUISITION REVIEW GUIDELINE MATRIX (CONTINUED)

DOCUMENTS	MILESTONE 0 (MENS Approval)	MILESTONE 1 (DSARC I)	MILESTONE 2 (DSARC II)	MILESTONE 3 (DSARC III)
	Concept Exploration	Demonstration & Validation	Full-Scale Development	Production
Request for Proposal	DARCOM-P 715-4 NAVMATINST 3960.9A AFR 80-5 AFR 800-12 AFR 800-17 AFLCR 57-11 AFSCP 70-4 MIL-STD 881 C-9	As in Concept Exploration V-8	As in Concept Exploration DoDI 500.29 DoDD 5100.40 DoDI 7900.1 DoDM 4120.3M AFR 66-14 AFR 300-10 AFR 800-14 AFLC/AFSCR 66-24 AFLCR 800-21 Production Phase RFP not addressed in Section 2.	
ILS Plan		DoDD 5000.39 AR 700-127/DARCOM Supp NAVMATINST 4000.20B AFR 800-8/AFSC & AFLC Supps AFSCP 800-21 AFLC/AFSCP 800-34 V-3	NAVMATINSTs 3960.9A & 4120.105 Plus As in Validation F-1	As in Validation and Full Scale Development P-1
ILS Source Selection Documentation		AR 715-6 NAVMATINST 4000.20B AFR 70-15/AFSC & AFLC Supps AFLC/AFSCP 800-34 V-5	As in Validation	
Logistics Element Budget Request		AR 11-18 AR 37-100 AR 70-32 NAVMATINST 4000.20B AFR 172-7	As in Validation F-6	P-6

TABLE D-1. WEAPONS SYSTEM ACQUISITION REVIEW GUIDELINE MATRIX (CONTINUED)

DOCUMENTS	MILESTONE 0 (MENS Approval)	MILESTONE 1 (DSARC I)	MILESTONE 2 (DSARC II)	MILESTONE 3 (DSARC III)
	Concept Exploration	Demonstration & Validation	Full-Scale Development	Production
Logistics Element Budget Request (Cont'd)		AFR 800-8 AFM 172-1 AFLC/AFSCP 800-34 AFLCM 172-1 V-6		
Logistics Element Test and Development Requirements			AR 700-127/DARCOM Supp OPNAVINST 3960.10 NAVMATINST 3960.6A AFR 80-14/AFSC Supp AFR 800-8 AFLC/AFSCP 800-34 F-2	
Test and Evaluation Master Plan			AR 70-10 OPNAVINST 3960.10 NAVMATINST 3960.6A AFR 80-14 AFLCR 80-4 F-4	As in Full-Scale Development P-5
Provisioning Conferences/ Allowance Documentation			AR 700-18 TM 38-715 (Army) NAVMAT P 4000-1 AFR 57-6 AFR 800-8 AFM 67-1 Joint Service SISMS Directive AFLC/AFSCP 800-34 MIL STDs 1552 and 1561 F-5	

TABLE D-1. WEAPONS SYSTEM ACQUISITION REVIEW GUIDELINE MATRIX (CONTINUED)

DOCUMENTS	MILESTONE 0 (MENS Approval) Concept Exploration	MILESTONE 1 (DSARC I) Demonstration & Validation	MILESTONE 2 (DSARC II) Full-Scale Development	MILESTONE 3 (DSARC III) Production
Operational Logistics Support Summary				DARCOM-R 11-27 NAVMATINST 4000.20B AFR 800-8 AFLC/AFSCP 800-34 P-7
ILS Verification & Audit Plan				AR 700-127/DARCOM Supp NAVMATINST 4000.20B AFR 800-8 AFLC/AFSCP 800-34 P-8
Transition Support Plans			AFR 800-4 with AFLC/AFSC Supps AFR 800-19 AFLC/AFSCR 80-17	AR 700-127/DARCOM Supp NAVMATINST 4000.20B AFR 800-4 AFR 800-8 AFLC/AFSCP 800-34 P-9
Computer Program Development & Quality Assurance Plan		DODD 5000.29 (Plan Initiated Prior to DSARC II and Fully Developed in Full-Scale Development Phase)	DODD 5000.29 AFR 800-14	As in Full-Scale Development

TABLE D-1. WEAPONS SYSTEM ACQUISITION REVIEW GUIDELINE MATRIX (CONTINUED)

DOCUMENTS	MILESTONE 0 (MENS Approval) Concept Exploration	MILESTONE 1 (DSARC I) Demonstration & Validation	MILESTONE 2 (DSARC II) Full-Scale Development	MILESTONE 3 (DSARC III) Production
Operational Logistics Support Summary				DARCOM-R 11 27 NAVMATINST 4000.20B AFR 800-8 AFLC/AFSCP 800-34 P-7
ILS Verification & Audit Plan				AR 700-127/DARCOM Supp NAVMATINST 4000.20B AFR 800-8 AFLC/AFSCP 800-34 P-8
Transition Support Plans			AFR 800-4 with AFLC/AFSC Supps AFR 800-19 AFLC/AFSCR 80-17	AR 700-127/DARCOM Supp NAVMATINST 4000.20B AFR 800-4 AFR 800-8 AFLC/AFSCP 800-34 P-9
Computer Program Development & Quality Assurance Plan		DODD 5000.29 (Plan Initiated Prior to DSARC II and Fully *Developed in Full-Scale* Development Phase)	DODD 5000.29 AFR 800-14	As in Full-Scale Development

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APPENDIX E

SUMMARY OF SUPPORT EQUIPMENT SELECTION ANALYSIS GUIDE (NAVY)

This appendix summarizes Naval Material Command Publication 9407, Support Equipment Selection Analysis Guide, November 1981. This guide describes the Navy's support equipment selection process and associated analytical methodologies for evaluating automatic test equipment (ATE) alternatives for meeting given test requirements. The analysis is intended to be conducted during the demonstration and validation phase of a weapons system acquisition program and to be completed early in the full-scale engineering development phase with identification of the optimum ATE. The analysis is normally tailored to the specific circumstances (considering need, schedule, and funds available) and is either conducted in-house, such as by the Naval Air Engineering Center, or contracted out to a third party.[1] It is essentially a Government tool for identifying the best ATE, considering current ATE inventory and Navy policies and programs, in lieu of the support equipment recommendation data prepared by prime contractors. The latter approach invariably results in system-peculiar ATE and schedule slippage, both of which can be avoided through the disciplined application of support equipment selection analysis (SESA). The SESA comprises the following six consecutive analyses conducted for each ATE alternative: (1) test requirements, (2) ATE capabilities, (3) unit-under-test (UUT)/ATE compatibility, (4) ATE loading, (5) life cycle cost, and (6) risk assessment. The analytic methods are briefly described below.

ELECTRONICS TEST REQUIREMENTS ANALYSIS

The first SESA consists of collecting UUT test requirements, usually from a preliminary test requirement document (TRD) at the weapon replaceable assembly level. Shop replaceable assembly

[1]For example, a contractor application of the analysis is described in: Dr. H. D. Kimp (M&T Company, King of Prussia, Pennsylvania), Support Equipment Selection Analysis (SESA) for the Navy Standard Airborne Computer Set (AN/AYK-14(V)). Report No. NAEC-92-138 (Lakehurst, New Jersey: Naval Air Engineering Center, 17 November 1980).

data are seldom available until start of full-scale engineering development. [Naval Air Systems Command uses its own specification for TRDs, Military Standard (MIL-STD) -2076(AS), "Unit Under Test Compatibility with Automatic Test Equipment, General Requirements For"; 1 March 1978, which is more detailed than the other available specifications.[2]] If the Contract Data Requirements List does not include delivery of a preliminary TRD, then that data must be collected by the SESA team.

As specified by MIL-STD-2076, the TRD includes both UUT data and test requirements data in a prescribed format. The UUT data include drawings, schematics, wiring diagrams, logic diagrams, functional block diagrams, parts list, design data, failure data, performance characteristics, and interface descriptions. (Some or many of these data may not be available in a preliminary TRD.) The UUT test requirements are specified both in parametric form and in ATLAS (Abbreviated Test Language for All Systems). (The latter is, of course, not available in a preliminary TRD.) Both the UUT data and test requirements are then summarized on UUT data sheets grouped into four functional areas: power supplies, digital signals, analog signals, and servo/synchro signals.

SUPPORT EQUIPMENT CAPABILITIES ANALYSIS

The second SESA is a systematic effort to delineate the test capabilities of each candidate ATE. Like the first, it is a data collection effort but includes a technical evaluation of the adequacy of test capabilities. The sources of data include the ATE data banks maintained by Navy activities (such as the Naval Air Engineering Center and Fleet Analysis Center) and other Department of Defense Components (e.g., San Antonio Air Logistics Center, San Antonio, Texas) as well as ATE manufacturers. The data are then summarized on support equipment data sheets containing general information and test capability specifications in the same four functional areas as listed for UUT data sheets.

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[2]MIL-STD-1519 (USAF), "Preparation of Test Requirements Document," 17 September 1971 (with Notice 1, 1 August 1977). MIL-STD-1345B (Navy), "Test Requirements Document," 10 February 1981. The Army's standard is a contractor-prepared document, Design Standard for the Development of AN/USM-410 Test Program Sets, RCA Document CR82-588-04, December 1982 (revised February 1984). This document does not include the term TRD, but directs that test specifications be included in the UUT data package, when possible.

COMPATIBILITY ANALYSIS

The third SESA consists of a detailed comparison of UUT test requirements with ATE capabilities to determine tester adequacy, identify any deficiencies and possible corrective actions, estimate cost factors, evaluate logistics support requirements, and assess technical risks. Depending on the scope of the SESA effort and the number of available ATE candidates, this analysis may also include technical definition of new ATE alternatives.

For the ATE-UUT comparison, available analytic and simulation models may be used. For each mismatch of test requirements and capabilities, further technical analysis is required to examine potential solutions, such as new interface devices, software modifications, or ATE modifications or as a last resort, new ATE. The result is a list of ATE alternatives for each UUT. The engineering and unit production costs of these alternatives are then estimated. Both the engineering and unit production costs are to include only those costs associated with supporting the specific UUT under consideration. To illustrate, for an existing tester the costs would include those for the interface device, test program set, and any tester modifications. Once those costs are estimated, the logistics support costs are estimated for each ATE alternative as well as the associated technical risk.

ATE LOADING ANALYSIS

The fourth SESA consists of evaluating the workload for each ATE alternative caused by the supported weapons system in order to determine the number of testers required as well as their utilization. This analysis requires an ATE installation site survey, information on weapons system mission requirements and reliability characteristics, estimated test run times, tester capacity in terms of available tester hours per month as a function of shift operations, ATE reliability and maintainability characteristics, and other existing workload (other than the target UUTs). The guide provides several factors for converting theoretical mean time between failure values to mean time between maintenance values so as to account for false removals. The guide also suggests that the user account for inefficiencies (ATE operator errors, job diversions) by reducing tester available hours by an empirically determined factor of 30 percent. The product of this analysis is a matrix showing the number of testers requested at each site and their utilization for each ATE alternative.

LIFE CYCLE COST ANALYSIS

The fifth SESA consists of quantifying the costs associated with the best ATE alternatives. This analysis is not a complete life-cycle-costing effort, but it is limited to the marginal costs that would be incurred for existing ATE. Those costs include nonrecurring, recurring, and operating/support costs. The guide includes a detailed cost element breakdown structure to aid in making the cost estimating effort consistent. It also lists various sources for cost data.

PROGRAM AND RISK EVALUATION

The final SESA, conducted concurrently with the previous analysis, addresses the risks involved for each ATE alternative. The potential risks include both technical risks (ATE and/or test program sets) and management risks. The guide devotes 32 pages to a discussion of these risks, but acknowledges that quantifying these risks in terms of probability of occurrence and resulting cost and schedule impacts may be an elusive task.

APPENDIX F

NAVY'S PLANNED APPROACH TO SERVICE WARRANTIES FOR COMMON ETE

(UNOFFICIAL)

This appendix provides the draft contract clause on "extended warranty" under the Navy's proposed approach for procurement of common electronic test equipment (ETE), whereby the service cost is included in the procurement cost. The following pages have been retyped from a copy of the draft contract clause received from the Navy.

<u>EXTENDED WARRANTY</u>

The Contractor warrants that the equipment furnished under this contract shall be free from defects in materials and workmanship for a period of 5 years and shall provide an option wherein the Navy may negotiate an extension of the warranted period for an additional 5 years. If products are found defective within the warranty period, the Contractor shall repair the defective equipment without charge for parts and labor. This warranty shall not preclude emergency repair and calibration actions by the Navy. Such actions shall be fully documented to the Contractor and subject to the "abuse" clause contained herein.

The Contractor shall designate at least ten service centers within the contiguous United States, and six service centers outside the contiguous United States for the purpose of equipment receipt from, and return to the Navy. The domestic service centers shall be located in or near Portsmouth, New Hampshire; Philadelphia, Pennsylvania, Norfolk, Virginia; Charleston, South Carolina; Orlando, Florida; San Diego, California; Los Angeles, California; San Francisco, California; Chicago, Illinois; and Seattle, Washington. Overseas service centers shall be located in or near London (England), Naples (Italy), Athens (Greece), Tokyo (Japan), Manila (The Philippines), and Honolulu, Hawaii. The Contractor shall mark each equipment delivered under this warranty with a large decal or other method to make it readily identifiable as a warranty item. The warranty decal

shall identify an 800 telephone number provided by the Contractor that can be used by the Navy to arrange calibration and repair actions into and from the designated service centers.

Under the terms of this warranty, operable equipment will be delivered to a service center by the Navy on a scheduled annual basis for refurbishment, calibration (including incidental repairs), and affixed with a calibration sticker. Inoperable equipment delivered to a service center shall be repaired and calibration recertified for a 12-month period. Replaced parts shall become the property of the Contractor. For each calibration and repair action, the Contractor shall annotate a METER card (calibration label) provided with the equipment in accordance with the MEASURE[1] Users Manual. If the Contractor deduces that the inoperable equipment has been abused, he shall notify the user and arrange for nonwarranty repair. Commander, Space and Naval Warfare Systems Command, Code 84110, Washington, D.C. 20363-5100 shall be provided written details of the equipment abuse. Equipment shall be returned to the service center within two calendar weeks for locations within the contiguous United States, and within three calendar weeks when shipping is required outside the contiguous United States (abused equipment shall be exempted from turnaround-time constraints). All shipping charges, taxes, duties, and associated costs incurred from the time the Navy delivers an equipment to a service center, to the time the Navy picks up the equipment, shall be borne by the Contractor.

A written, semiannual report shall be made to Space and Naval Warfare Weapons Command Code 84110 by the Contractor. The report shall delineate repair and calibration transactions with dates of equipment receipt at a service center and when the equipment is available for pick-up by the Navy. Transactions shall be annotated with a positive value in days ahead of its respective delivery schedule and a negative value in days behind. A zero value shall indicate on schedule. The values shall be totaled for the semiannual period. The Contractor shall incur a penalty at the equivalent rate of $200 per day for a negative total. This penalized amount will be subsequently used by the

[1]Metrology Automated System for Uniform Recall and Reporting.

Navy to offset costs for scheduled Contractor's services for repair of abused equipment or other nonwarranted repair services at the current published Contractor charges.

For the purpose of this extended warranty, the following definitions apply:

- Calibration: The process of comparing an instrument of unverified accuracy to a certified standard of greater accuracy, traceable to the National Bureau of Standards, to detect and correct all variations from the manufacturer's published specifications for the instrument.

- Incidental repair: Those repairs found necessary during calibration of operable equipment to bring it within its specified tolerances, including the replacement of parts which have changed value sufficiently to prevent certification but do not otherwise render the equipment inoperative. The term "incidental repair" does not apply to inoperable equipment.

- Operable equipment: Equipment which, from its most recent performance history and a cursory electrical and physical examination, displays an indication of operational performance for all required functions when submitted for calibration.

- Repair: The restoring of the instrument, both electrically and mechanically, so that it will meet all of the instrument manufacturer's published specifications as verified by calibration.

- Refurbishment: Preventative maintenance actions intended to maintain the equipment in ready-for-use status.

- Abused equipment:

  - Physical abuse: Damage associated with the improper handling of test equipment such as dropping, throwing, or other mechanical stress which results in damage not associated with normal use.

  - Electrical abuse: Damage to circuitry because of overloading (such as the input of excessive RF energy).

  - Cannibalization: Defined as the stripping of good components or assemblies from one instrument to repair another instrument. This abuse is indicated by the presence of two or more unrelated failures.

  - Improper or detrimental emergency repair by the Navy.

- Service Center: A designated point of entry for the receipt of equipment from the Navy and return thereto.

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UNCLASSIFIED

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Since the early 1970's, the Office of the Secretary of Defense, the Military Departments, and industry have sponsored numerous studies of test equipment, formed several joint panels to investigate selected technical issues, and initiated a variety of programs to correct identified problems. Despite such attention, the Department of Defense still faces many significant problems with fielded test equipment.

In a previous report, Test Equipment Management, January 1985, we summarized the nature and extent of those problems and recommended the Assistant Secretary of Defense (Manpower Installations, and Logistics), ASD(MI&L), take the lead in effecting needed improvements in test equipment management and support. The ASD(MI&L) concurred with that recommendation and established, via an action memorandum for the Under Secretaries of the Military Departments, dated 26 June 1985, a "DoD Test Equipment Management Improvement Program" under the overall guidance of his Maintenance Directorate.

Since the issuance of that action memorandum, the Maintenance Directorate has been coordinating DoD-wide efforts to implement the DoD Test Equipment Management Improvement Program. This report, which is published in four volumes, bolsters the Maintenance Directorate's initiative. Volume I lays out a specific program of action for the Assistant Secretary of Defense (Acquisition and Logistics) to serve as a cornerstone for the DoD Test Equipment Management Improvement Program; Volume II reviews previous studies and initiatives pertaining to test equipment management and support; Volume III describes how the Military Departments are organized to carry out that management and support; and Volume IV reviews and assesses the adequacy of DoD policy.

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